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R 503

Technical Report

ENGINEERING PROPERTIES OF MARINE SEDIMENTS NEAR SAN MIGUEL ISLAND, CALIFORNIA

December 1966

NAVAL FACILITIES ENGINEERING COMMAND

U. S. NAVAL CIVIL ENGINEERING LABORATORY

Port Hueneme, California

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ENGINEERING PROPERTIES OF MARINE SEDIMENTS NEAR SAN MIGUEL ISLAND, CALIFORNIA

Technical Report R-503

Y-F015-01-02-001

by

Melvin C. Hironaka

ABSTRACT

In April 1964 study was begun of the ocean floor at the proposed site for emplacing Submersible Test Unit II (STU II) series to determine whether the floor would provide a suitable foundation for the STUs. Eight sediment cores were taken to determine the engineering properties of the sediments in an area approximately 2 miles square in the vicinity of 34° 05.5'N, 120° 43.0'W, some 14 miles west of San Miguel Island, California. In addition, a bathymetric chart of the area was constructed using data from the precision depth recorder and navigational instruments aboard the USS Molala. Laboratory tests were conducted on core samples and computations of bearing capacity and settlement were made for the area with the resulting data. The calculated average bearing capacity was 300 pounds per square foot. The applied load of the STU was approximately 110 pounds per square foot. The calculated total settlement was 1.7 inches.

The test results were analyzed statistically to determine the relationships (1) between vane shear strength and depth below the sediment surface, liquid limit, and median particle diameter; and (2) between bulk wet density and vane shear strength and sensitivity. The results indicate the correlations are satisfactory for use in site reconnaissance and site selection studies.

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The Laboratory invites comment on this report, particularly on the results obtained by those who have applied the information.

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INTRODUCTION

The Naval Civil Engineering Laboratory is studying the effects of the deep ocean environment on construction material[1] in conjunction with the deep ocean engineering program. To accomplish this task, submersible test units (STUs)[2] have been designed and placed in selected locations off of the Santa Barbara Channel Islands along the coast of southern California. In support of this project, the ocean floor features at these sites have been studied to determine the suitability of the sites as foundations for the STUs. This report presents the results obtained from the investigation of the STU-II site, which is the shaded area shown in Figure 1. This study began in April 1964.

This report covers (1) the sampling and testing procedures used in this study of marine sediments, (2) the results of tests and foundation analysis, and (3) a statistical analysis of the relationships between (a) vane shear strength and bulk wet density, and (b) various laboratory-measured properties of the sediments.

SAMPLING PROCEDURE

The USS Molala was used for all the bathymetric survey and sampling phases at sea. The precision depth recorder and the navigation equipment aboard the vessel were used in the bathymetric survey phase. All locations were referenced to Richardson's Rock by using radar and dead reckoning methods of positioning.* The detailed bathymetric chart of the STU-II site as shown in Figure 2 was then constructed from the data obtained from this survey.

During the coring phase, the vessel was maneuvered into the preselected position of each core and all engines were secured. The assembled coring apparatus was then lowered until a sample was obtained, at which time the location of the vessel, water depth, and other identifying data were logged. The vessel was not equipped for maintaining precise positions in the open sea; therefore, some drift of the vessel occurred during the sampling interval. The coring phase continued until eight cores (Table 1) were secured. The entire coring operation was accomplished within an elapsed time of 10 hours. All of the sediment cores were obtained using a Ewing-type gravity coring apparatus (Figure 3) for which characteristic data is shown in Table 2.

*The LORAC positioning system was not available at NCEL at the time of this study.

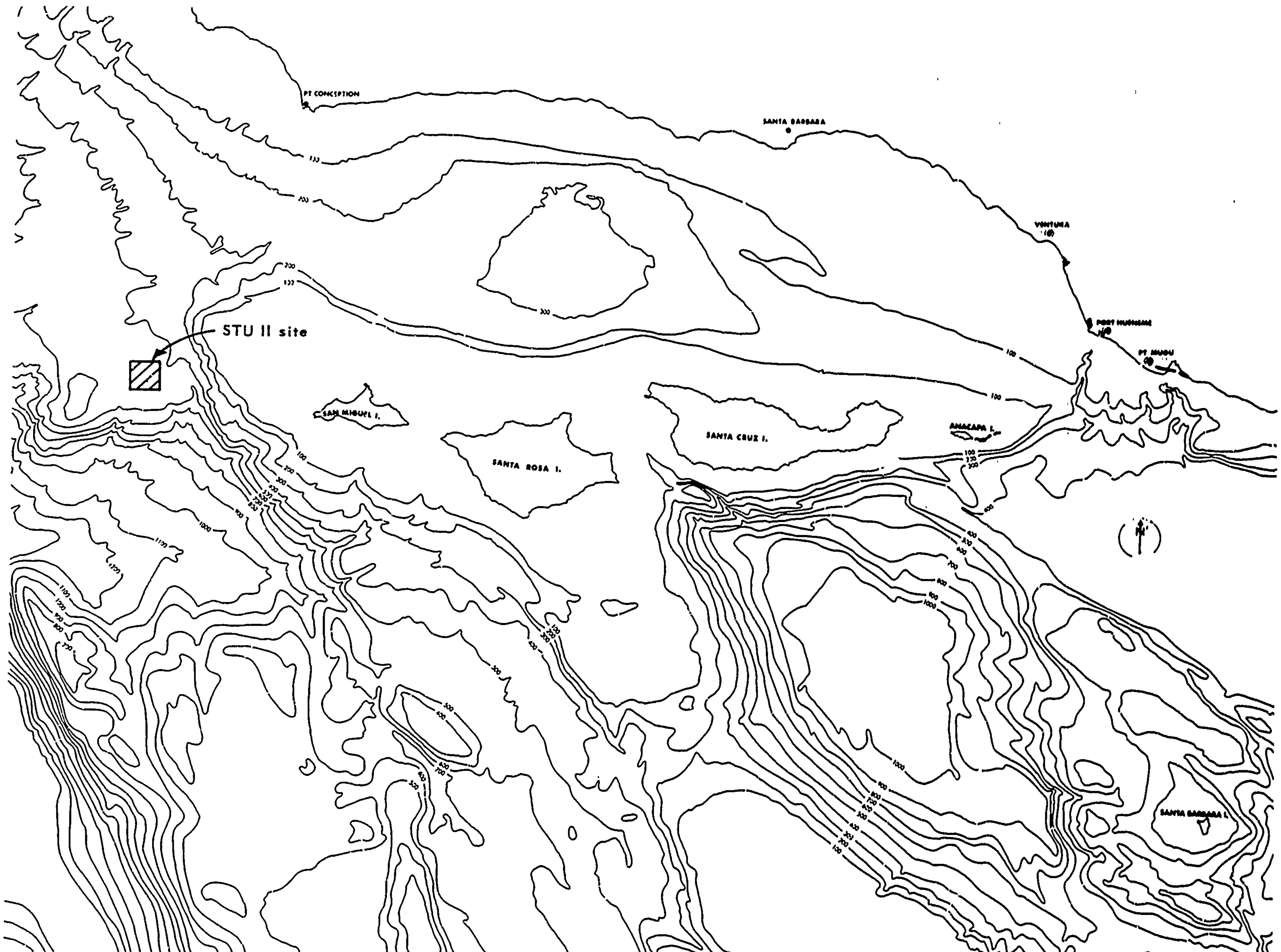

Figure 1. Map showing general location of STU II site.

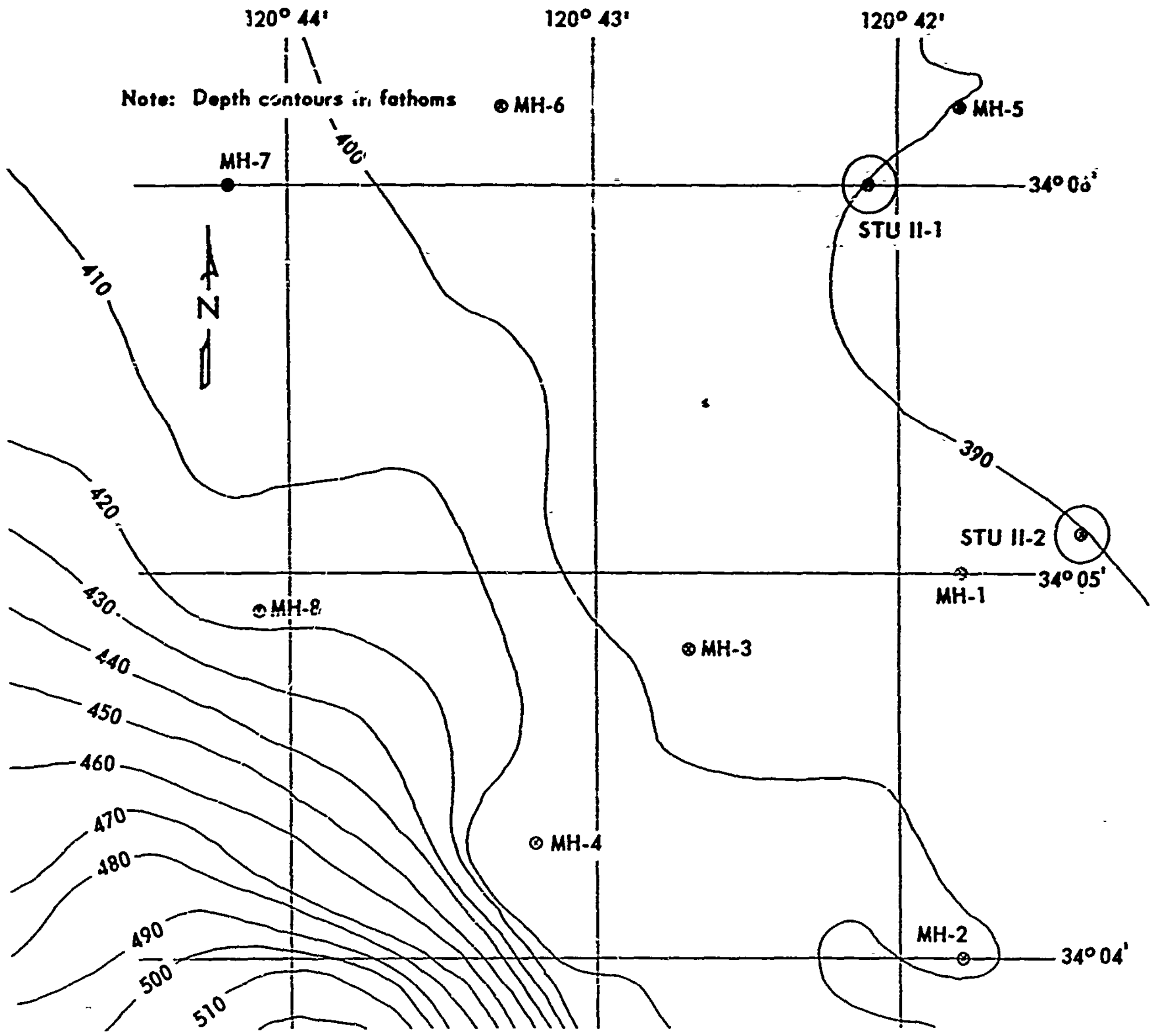

Figure 2. Bathymetric chart of STU II site showing locations of core samples and STUs.

Table 1. Data on Core Samples Taken on 7 April 1964[1,2]

Sample No.	Time (PST)	Latitude (N)	Longitude (W)	Water Depth (fathoms)	Core Length (in.)
MH-1	1012	34° 05.0'	120° 41.8'	392	27
MH-2	1106	34° 04.0'	120° 41.8'	412	5
MH-3	1252	34° 04.8'	120° 42.7'	396	26
MH-4	1350	34° 04.3'	120° 43.2'	403	11
MH-5	1444	34° 06.2'	120° 41.8'	388	30-1/2
MH-6	1548	34° 06.2'	120° 43.3'	395	32
MH-7	1637	34° 06.0'	120° 44.2'	404	15
MH-8	1958	34° 04.9'	120° 44.1'	408	26

1/ Penetration not recorded.
2/ Free-fall height 6 feet.

Figure 3. Rigging the coring apparatus.

Table 2. Coring Apparatus Specifications Data

Corer	
Type	Ewing
Manufacturer	Alpine Geophysical Associates, Inc.
Weight (assembled, submerged)	360 lb (approx.)
Piston type	None used
Inside clearance ratio 1/	0.019
Outside clearance ratio 1/	0.182
Area ratio 1/	0.979
Core Barrel	
Length	8 ft 0 in.
Inside diameter	2.508 in.
Outside diameter	2.750 in.
Cutting Edge	
Length	4.625 in.
Inside diameter	2.375 in.
Outside diameter	3.250 in.
Taper of edge	11° 38'
Sample Retainer	
Type	Finger (brass)
Length	3 in.
Inside diameter	2.31 in.
Plastic Liner	
Type	Cellulose acetate butrate
Inside diameter	2.355

1/ From Reference 3.

The equipment and sampling capabilities to preserve in-situ conditions such as pore pressure, temperature, and salinity of the samples were not available at the time of this study. However, the samples were guarded against other physical disturbances. The core samples were stored vertically on board the vessel in a honeycomb compartment box, each core in an individual cell. When the samples were delivered to NCEL, they were stored in a controlled-humidity room until the physical testing could be conducted about a week later.

TESTING EQUIPMENT AND PROCEDURES

These cores were tested in the laboratory using soil-testing methods described by References 4, 5, 6, 7, and 8. The general routine laboratory procedure that each sample was subjected to is described by Smith and Hironaka.[9] The first step in the testing routine was removal of a 3-inch interval from a sample by the sectioning method described by Smith and Nunes.[10] The test sequence which this section and the other sections tested* then underwent was:

1. Bulk wet density
2. Vane shear strength (undisturbed sample)
3. Original water content
4. Vane shear strength (remolded sample)
5. Atterberg limits
6. Specific gravity
7. Grain-size analysis
8. Carbonate-organic carbon analysis

Special equipment used in the tests was the vane shear testing apparatus, the air-comparison-type pycnometer for specific gravity determination, and the carbon determinator for carbonate and organic carbon analysis. The vane shear testing apparatus (Figure 4) developed by Smith** is unique because the complete record of the shear test is automatically recorded. The sample is placed on the pedestal which is driven by a synchronous motor geared to obtain a constant angular velocity of 1 revolution per hour. The vane is then introduced into the sample and the pedestal rotation initiated. The calibrated torque output from the vane is then measured through an instrumented cantilever reed system and recorded on a constant-velocity chart. A complete history of the shear failure is therefore recorded on this chart.

*Every other 3-inch interval was tested.

**U. S. Naval Civil Engineering Laboratory. Continuous recording vane shear apparatus, by R. J. Smith, Ph D. Port Hueneme, Calif. (unpublished manuscript)

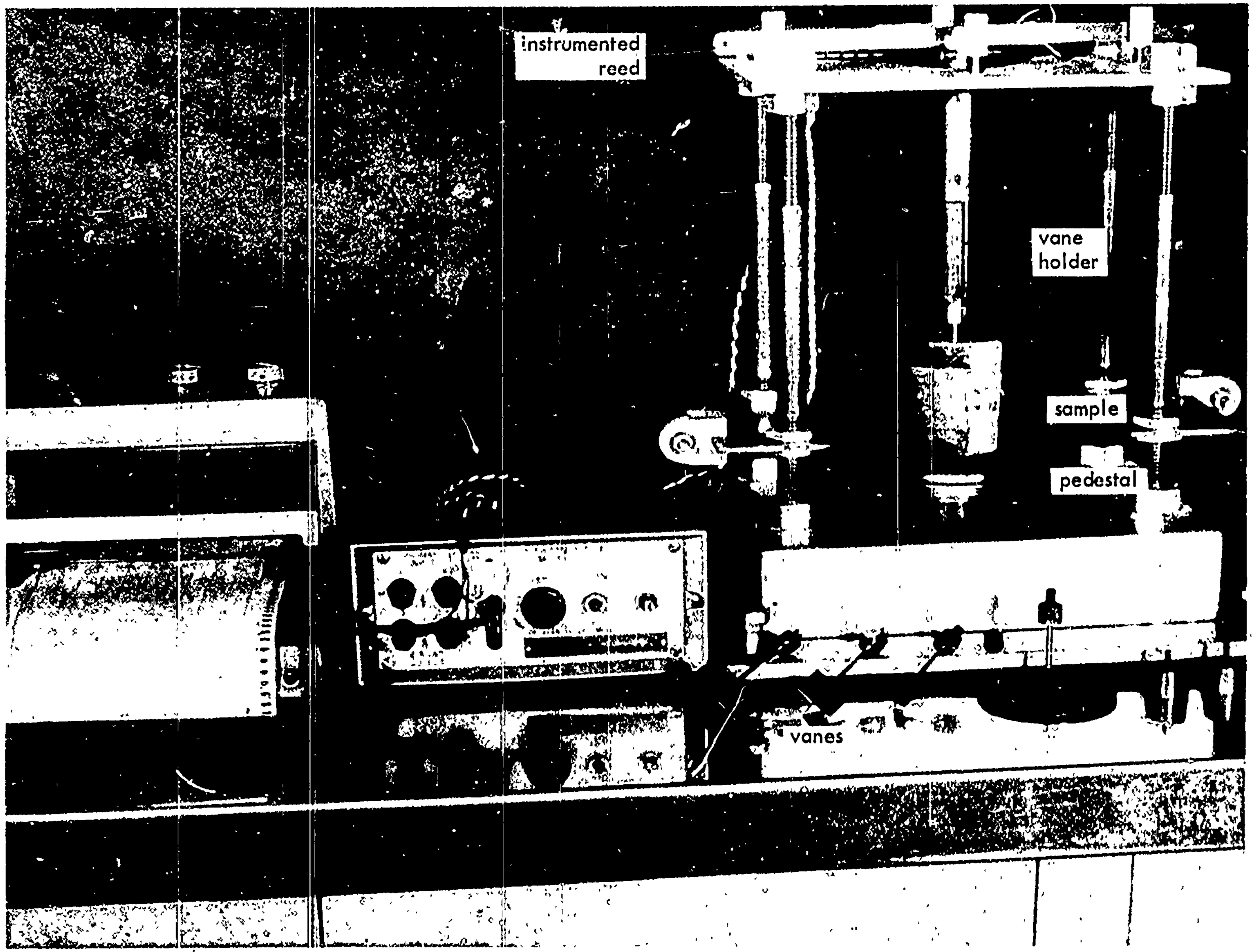

Figure 4. Vane shear apparatus with sample being tested.

The air-comparison-type pycnometer shown in Figure 5 was used for all the specific gravity determinations. This pycnometer has two chambers (designated as measuring and reference) calibrated to a known volume. A known weight of dry sample was subjected to a partial vacuum in the measuring chamber. At this pressure, the change in volume of the measuring chamber relative to the reference chamber was taken as the volume of the solid particles. The volumes of the solid particles measured by this method appear to be closely camparable to those measured by the accepted ASTM[4] method. This method offers the advantage of being rapid in that each test can be accomplished in approximately 5 minutes.

Carbon content determinations were made with a carbon determinator (Figure 6) utilizing an induction furnace and an oxygen combustion medium. This type of apparatus is commonly used in industry to measure the carbon content of structural steel and other metals. Each sample was divided into two parts. Approximately 1/2 gram of sample from the first part was weighed and placed in a combustion crucible, treated with hydrochloric acid to remove the carbonate carbon, rinsed with distilled water, and dried in an oven. Approximately the same amount from the second part was weighed and placed in a second crucible. Tin-coated copper and iron chip accelerators were then placed in each crucible and the separate tests conducted.

The visual observation procedures which require some explanation are the color determination, core logging, and microscopic analysis. Color determinations were made by visual comparison with a rock color chart.[11] This determination was done immediately upon removal of each 3-inch section of a sample. The intermediate sections which were not tested in the above procedures were split longitudinally to obtain additional information for the core log. The microscopic analysis of the plus 325-mesh fraction obtained from the grain size analysis was accomplished using a binocular microscope. The core log and the microscopic analysis were made after the above tests.

DATA REDUCTION METHODS AND RESULTS

Data reduction was done by computer methods described in detail by Hironaka.* Three basic computer programs for the IBM 1620 Model II at NCEL were used to reduce all test data. The results of the data reduction are presented in Tables A-1 through A-8 of Appendix A. The data in each table represents one core sample. The values presented are self-explanatory in most cases.

Methods for determining values for liquid limit, compression index, carbonate content, organic content, and sediment type require some explanation, since there are other methods for obtaining these values. By using the familiar liquid-limit

*U. S. Naval Civil Engineering Laboratory. Computer reduction of soil test data, by M. C. Hironaka. Port Hueneme, Calif. (in preparation)

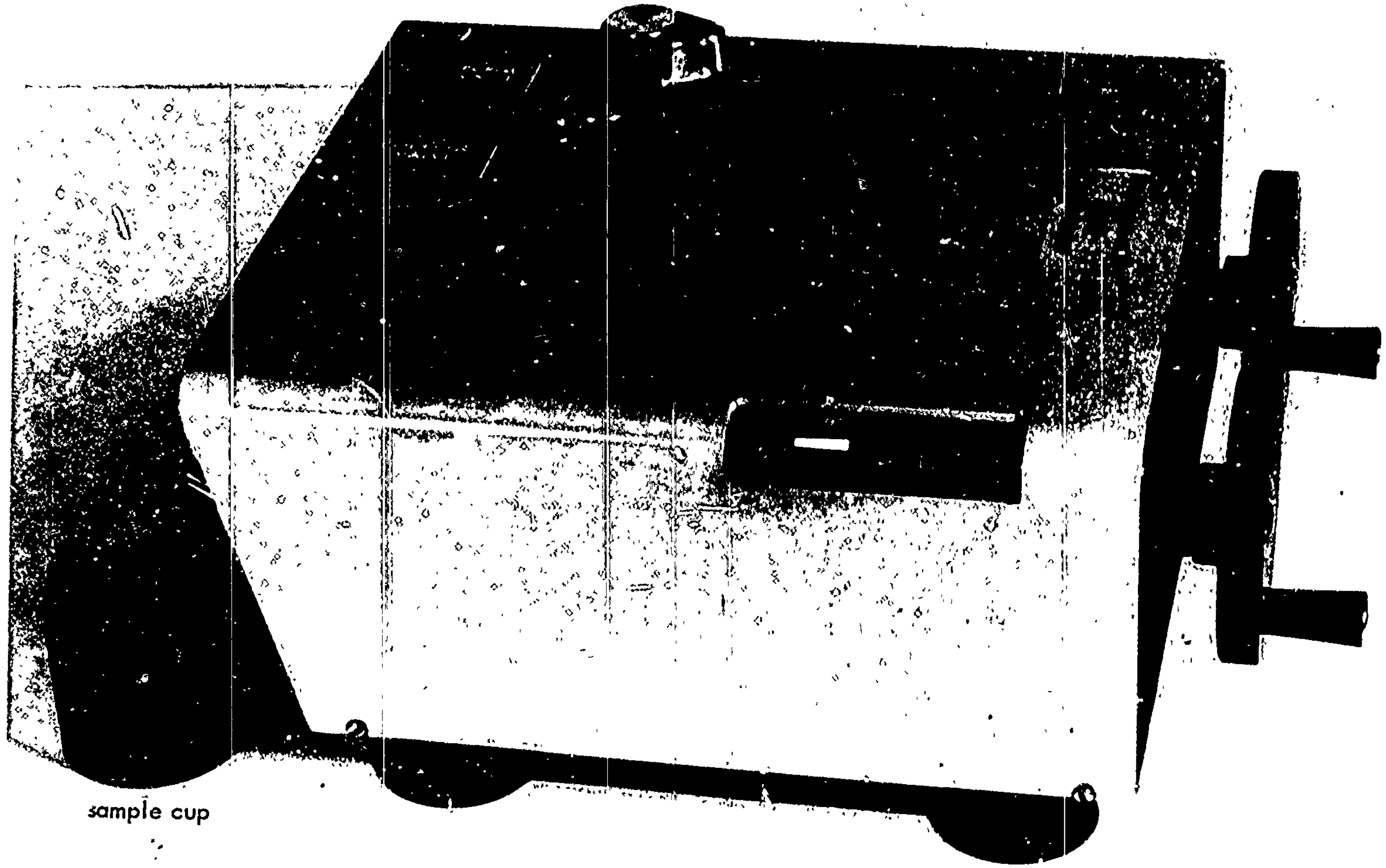

Figure 5. Air-comparison-type pycnometer used to determine specific gravity.

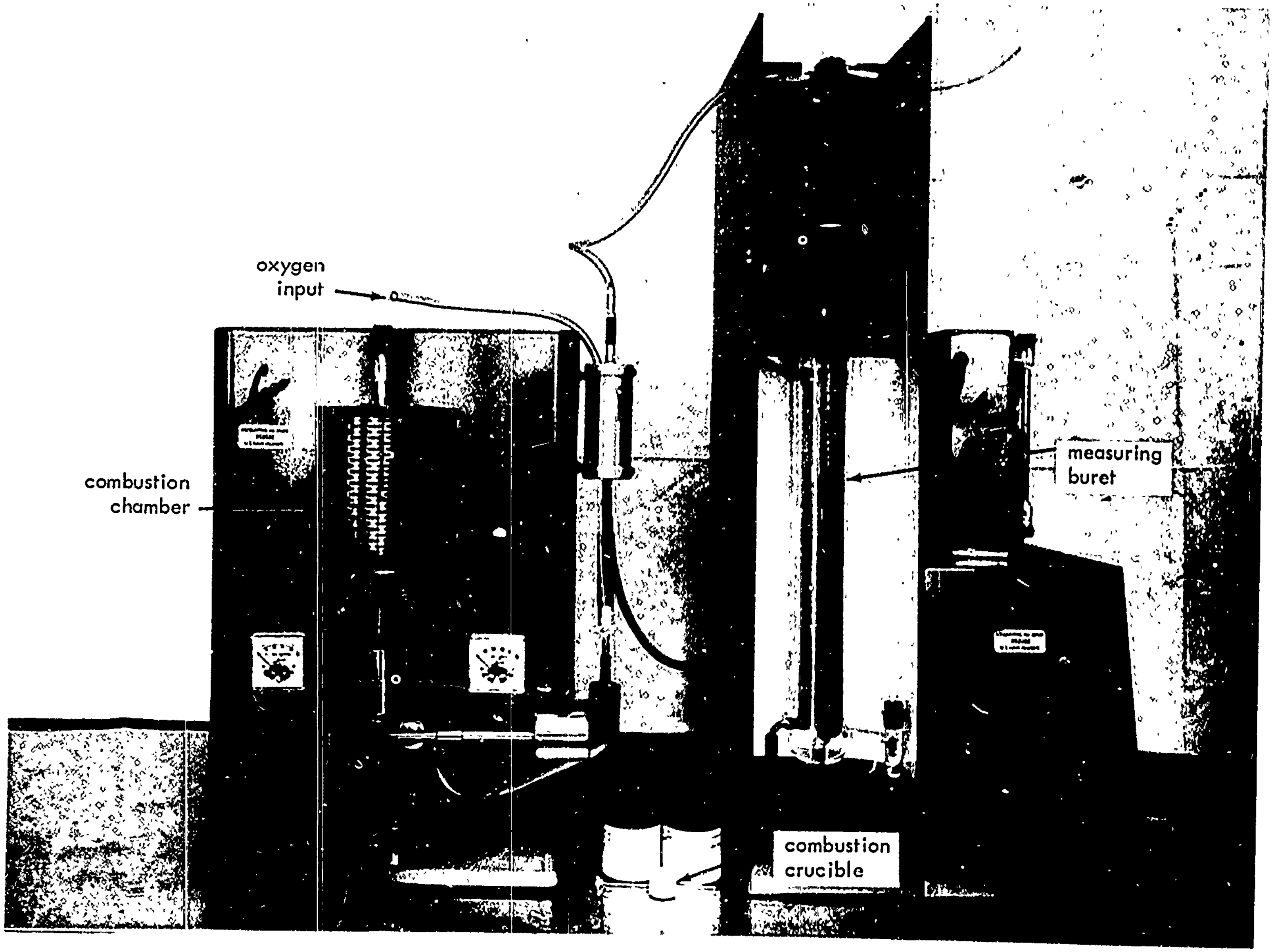

Figure 6. Carbon determinator used in carbonate-organic carbon analysis.

mechanical device, the liquid limit was determined by the one-point method as described by Joslin and Davis.[12] An approximation of the compression index was made by using the relationship[13]

$$CI = 0.009(LL - 10)$$

where CI = compression index

LL = liquid limit

Carbon content in the form of calcium carbonate and organic matter was determined by the following relationships:

Carbonate content (%) = (% carbon, untreated sample minus % carbon, treated sample) x 8.3

Organic content (%) = (% carbon, treated sample) x 1.7

The gravimetric factor, 8.3, was obtained from the relationship between the atomic weight of carbon and the molecular weight of calcium carbonate. The factor 1.7 was obtained from Reference 14. Sediment type was determined from the usual trilineal plot of sand-silt-clay percentages modified by Shepard[15] for marine sediments. All other test results shown in Tables A-1 through A-8 are derived by the standard computational methods used in soil investigations.

Dating of the samples was done by paleontological methods by Carson.* The microfaunas and lithology of all eight samples were reported to be very similar. An exact date could not be assigned, however, because (1) the samples were from an offshore marine environment in which no overlying sediments were present that could be classified as Recent, (2) the foraminifera all represented living species, and (3) the beds were not folded. However, for the environmental conditions at the location of the samples (depth of water, 2,000 to 4,000 feet; temperature, 3° to 5°C), the age of the sediments could be from early Pliocene to Pleistocene.

DISCUSSION

Test Results

The test results fall into two basic categories. The first category, the observed values of the sample, includes color, odor, microscopic analysis, and the features described in the core log. The second category, the measured and computed values of the sample, includes those values that are obtained from the laboratory testing procedures listed earlier.

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* Offshore Punch Core Samples, by Carlton M. Carson, Consulting Paleontologist. Ventura, Calif., April 1966 (Memo to R. J. Smith).

In observed values, the samples were quite similar. The color variation was narrow, ranging from a moderate olive brown (5Y 4/4) to an olive gray (5Y 3/2).[11] Four of the core samples (MH-1, 4, 7, 8) tended to become darker to olive gray with depth of the sample. The other four samples were somewhat uniform moderate olive brown. Hydrogen sulfide odor was present throughout the samples. No degree of difference in intensity of the odor was noticed.

In the microscopic analysis it was observed that the plus-325-mesh fraction contained principally glauconite, quartz, and foraminifera (both planktonic and benthonic). Glauconite was the primary constituent in the coarse fraction of samples MH-1, 2, 3, and 4, while quartz was the primary constituent in samples MH-5, 6, and 7. Sample MH-8 had approximately an equal amount of glauconite and quartz. There appears to be an abrupt change in glauconite concentration between the above two groups of samples. This may be indirectly related to the high bottom currents (maximum 0.4 knot — average 0.1 knot at 4 feet above the ocean floor recorded during STU II-1 exposure) and the associated temperature and salinity differences between the water masses merging in this vicinity. This abrupt change in glauconite concentration has also been observed by Wright,* who has conducted extensive research in this general area. Benthonic and Planktonic foraminifera were present in minor amounts in all of the samples. Samples MH-5 and 6 contained a larger percentage of foraminifera than the others.

In the core-logging process, there were no observed features that would be detrimental to the stability of the structure. There were no weak layers that could be classified as being the seat of settlement observed in the sediment columns retrieved. Samples MH-2 and 4 had a layer of pebbles at the base which stopped the passage of the corer.

In measured and computed values, the samples were quite similar. Figures B-1a to B-7b of Appendix B are plots of the results. Bulk wet density, vane shear strength of undisturbed samples, vane shear strength of remolded samples, and dry density appear to increase with depth in the core. Deviation of these values from this trend towards the base of the core is probably due to disturbance during the coring process rather than a stratigraphic condition. The values for sensitivity, water content, void ratio, porosity, and saturated void ratio, appear to decrease with depth in the core. The remaining measurements did not show any noticeable trend relative to depth. The plastic limit was not obtainable because the samples were coarse grained. As a result, the plasticity index, liquidity index, and activity values could not be computed. By Shepard's trilineal classification plot, the sediments had classifications in the sand, clayey sand, and silty sand groups. Sand constituted between 64% and 81%, silt between 9% and 18%, and clay between 10% and 18% (by weight) of the sediments. Specific gravity of solids ranged from 2.608 to 2.843. Median diameters ranged from 0.068 to 0.214 mm.

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*F. F. Wright, Marine Geology of San Miguel Gap, Off Point Conception, California. Ph D Dissertation, Department of Geology, University of Southern California (in preparation).

The glauconite-abundant samples (MH-1, 2, 3, and 4) possessed some physical properties differing from those of the quartz-abundant samples MH-5, 6, and 7. The average median diameter and specific gravity for the first group of samples were 0.118 mm and 2.752, respectively. For the second group, the average median diameter and specific gravity were 0.076 mm and 2.716, respectively. The glauconite-abundant samples had a smaller average carbonate content (10.59%) than the quartz-abundant samples (15.77%). A relationship may exist between glauconite formation and foraminifera activity.

There appears to be a zone of minimum carbonate in some of the samples that may be significant geologically. This zone is located approximately 15 inches from the sediment surface. The specific gravity values tend to increase in this zone, which is as expected, since carbonates in the form observed in the microscopic analysis have lower specific gravities than glauconite and quartz. Since these carbonates are at a minimum in this zone, the average specific gravity would therefore be higher.

Foundation Analysis

Assuming that ocean-floor sediments can be treated as submerged terrestrial soils, the concepts of foundation analyses used for terrestrial soils were applied in this study. Since the health and welfare of personnel were not dependent on the stability of the structure and its foundation, and because the total cost of the STU was not great, a detailed foundation analysis was not warranted. A very brief analysis was made to determine the stability of the foundation.

The proposed submersible test units had the following characteristics:

Weight — STU II-1: 7,350 pounds (in air)

STU II-2: 8,750 pounds (in air)

Footing — Two plates: 3 feet 2 inches by 12 feet 6 inches

Depth of footing below sediment surface — 0 feet

The ultimate bearing capacity of the soil (p_{max}) was calculated using the equation presented by Tschebotarioff:[16]

$$p_{max} = 5.52c\left(1 + 0.38\frac{h}{b} + 0.44\frac{b}{L}\right) \qquad (1)$$

where c = cohesion

h = depth of footing below soil surface

b = breadth of footing

L = length of footing

It should be noted that this equation considers the soil to be entirely cohesive; that is, the angle of internal friction is zero. An average value of cohesion, obtained using the vane shear technique, was used in this analysis. This approach was used because the sediments at the site were soft and could not be routinely evaluated using direct shear or triaxial testing procedures. Additionally, sample disturbance received during coring does not justify such elaborate shear strength measurements. Sample disturbance has been discussed in greater detail by Inderbitzen.[17]

The applied stress due to the weight of the STU was 110 pounds per square foot. The ultimate bearing capacity of the supporting sediments according to Equation 1 was 300 pounds per square foot and, therefore, a factor of safety in bearing of approximately 3 existed.

A settlement analysis was made using the data presented herein and methods outlined by Hough,[18] and Terzaghi and Peck.[13] A plot of void ratio versus effective stress (Figure 7) was developed using compression indexes computed as previously discussed. The solid lines on Figure 7 are e log p curves drawn for the limiting values of void ratios and compression indexes. The dashed line indicates the compression index and the corresponding void ratios which were used for this analysis. This compression index was selected to compensate for the low crushing strength of the glauconite grains. It is interesting to note that the minimum void ratios determined by this method correspond well with those suggested by Hamilton.[19] The analysis was made assuming that significant compressions occur only within the soil layer extending from footing grade to the level at which the effective applied stress equals 10% of the effective overburden stress. The distributed effective applied stress was calculated using the 60-degree approximation method described by Hough:[18]

$$\Delta p = \frac{A_1}{A_2} \Delta p_f$$

where Δp = change in effective stress due to the applied load

A_1 = area of footing

A_2 = area at depth Z

Z = depth below footing grade

Δp_f = bearing pressure at footing grade due to the applied load = 110 psf

The applied effective stress at any depth, Z, expressed in terms of the dimensions of the STU and the bearing pressure at footing grade is:

$$\Delta p = \frac{(3.167)(12.5)(110)}{(3.167 + Z)(12.5 + Z)} \qquad (2)$$

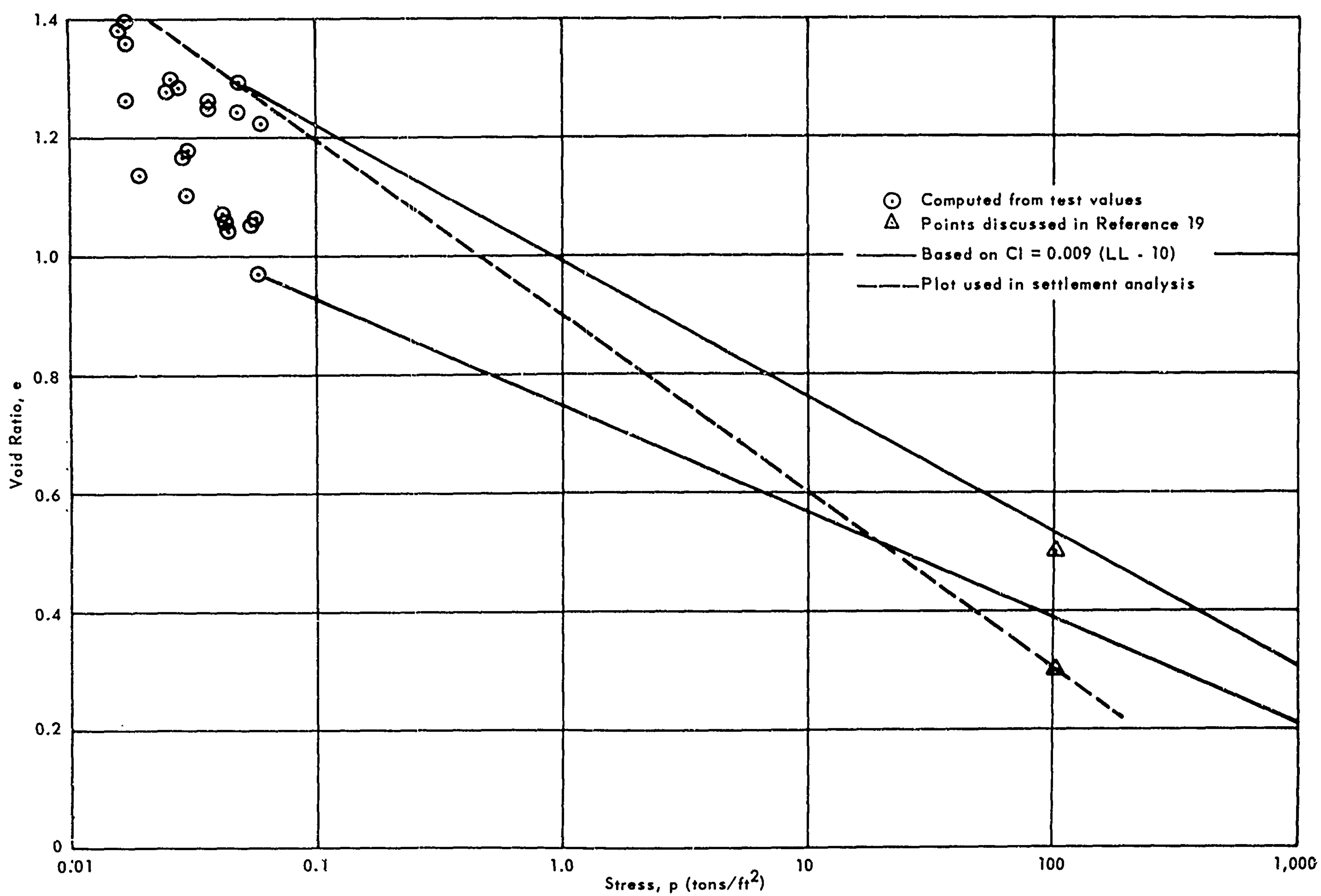

Figure 7. e log p diagram for settlement computations.

According to the assumptions

$$\Delta p = (0.1)\gamma' Z \tag{3}$$

where γ' = submerged unit weight of the sediment. Solving Equations 2 and 3 simultaneously, the depth of significant stress was determined to be 5.8 feet. An estimate was made of the total settlement within this depth using the following equations:

$$\Delta H_i = H \frac{C_c}{1 + e_o} \log\left(1 + \frac{\Delta p}{p_o}\right) \tag{4}$$

$$S = \sum_{i=1}^{n} \Delta H_i \tag{5}$$

where ΔH_i = change in thickness of layer

H = initial layer thickness

C_c = compression index

e_o = initial void ratio

Δp = change in effective stress due to the applied load

p_o = initial effective stress

S = total settlement

n = number of layers

The total settlement was computed to be 1.7 inches. This calculated settlement is not excessive and is tolerable for this type of structure. In most foundation analyses for ocean floor structures, as in this analysis, settlement considerations rather than bearing capacity of the supporting sediments will govern the design because pelagic sediments are usually highly compressible, normally consolidated clays. In recent research on consolidation characteristics of pelagic sediments, Nielsen[20] discusses this in greater detail.

The actual total settlements of the structures were determined from mudline markings on the material specimens exposed to the sediment environment. These specimens extended 6 inches below the bottom of the bearing plates. On STU II-1, the mudline markings on the specimens ranged from zero to 8 inches. For this STU the total maximum settlement was approximately 2 inches, which compares favorably with the calculated value of 1.7 inches. On STU II-2, the mudline markings ranged from 1/4 inch to 6 inches. The total settlement was negligible in this case. From markings on the specimens on both STUs, it appears that either the ocean floor was very irregular or that scour or fill occurred. It was not readily apparent if the structures were subjected to differential settlements.

Statistical Evaluation of Test Data

In the future, as activity in the deep ocean environment increases, the need for site reconnaissance and selection information on specific ocean floor areas will be required. In anticipation of this need, the test results from the cores were analyzed statistically to determine if there were any significant correlations between (1) vane shear strength and bulk wet density and (2) the various laboratory measured properties of the samples. It is expected that these correlations will be used in making bearing capacity and settlement estimates in site reconnaissance and selection studies. For example, it may become necessary to determine values for vane shear strength of a core sample taken for other purposes and tests or which has desiccated from long storage. Also, as in-situ testing procedures progress at NCEL and other activities, it will be necessary to correlate bulk wet density values with in-situ test values. For example, settlement estimates may be required for a specific ocean floor site from which in-situ vane shear values are available. By the use of the correlation, estimates of bulk wet density may be made to be used in calculating settlement estimates.

By using a stepwise regression analysis procedure,[21] two separate linear regression analyses were conducted. The first analysis was made to determine the relationship between vane shear strength and the various index and measured properties. The second analysis was made to determine similar relationships for bulk wet density. It was found that vane shear strength was dependent on depth below the sediment surface, liquid limit, and median diameter of the sediment. Bulk wet density was dependent on vane shear strength and sensitivity. Although these analyses were based on laboratory measured values, it is believed that these relationships are also valid for in-situ values. Later, as in-situ vane shear data become available, the relationship between laboratory measured and in-situ measured vane shear values can be validated.

The equation derived for the vane shear strength is:

$$VSS = k_1(D) + k_2(LL) + k_3(MD) + k_4 \qquad (6)$$

where VSS = vane shear strength, psi

D = depth in sediment, in.

LL = liquid limit, %

MD = median diameter, mm

k_n = constants (n = 1, 2, 3, 4)

The values computed for k_n for this set of data are

$$k_1 = 2.34 \times 10^{-2} \qquad k_3 = 1.43 \times 10^{-1}$$

$$k_2 = -2.72 \times 10^{-3} \qquad k_4 = 3.64 \times 10^{-1}$$

In Figure 8 the calculated vane shear strength using the above equation and constants is shown plotted against the measured vane shear strength. The points are somewhat dispersed about the 45-degree line; however, there is a definite direct correlation between the measured and calculated values.

The substitution of the constants into the equation, however, does not give a general equation which can be used for all ocean floor areas. Therefore, the problem at the moment is to determine the values for the constants k_n for given bottom terrain areas. One solution would be to use four equations with different values for the constants k_n to represent the four general terrain types of the ocean bottom which can be classified as the continental shelf, continental slope, low rise, and basin areas.

It must be noted that sampling technique (e.g., the use of a piston) and coring apparatus characteristics (e.g., area ratio of cutting nose[3] and the inside diameter of the sampler), will affect the constants k_n. Once the influence of the sampling technique and the sampler characteristics on the constants is determined, the four equations can be derived with sufficient data from the four terrain types.

The equation derived for bulk wet density is in the form

$$BWD = c_1(VSS) + c_2(SN) + c_3 \tag{7}$$

where BWD = bulk wet density, gm/cc

VSS = in-situ vane shear strength, psi

SN = in-situ sensitivity

c_n = constants (n = 1, 2, 3)

For this particular set of data, the values computed for c_n are

$$c_1 = 9.87 \times 10^{-2}$$

$$c_2 = -5.71 \times 10^{-2}$$

$$c_3 = 1.843$$

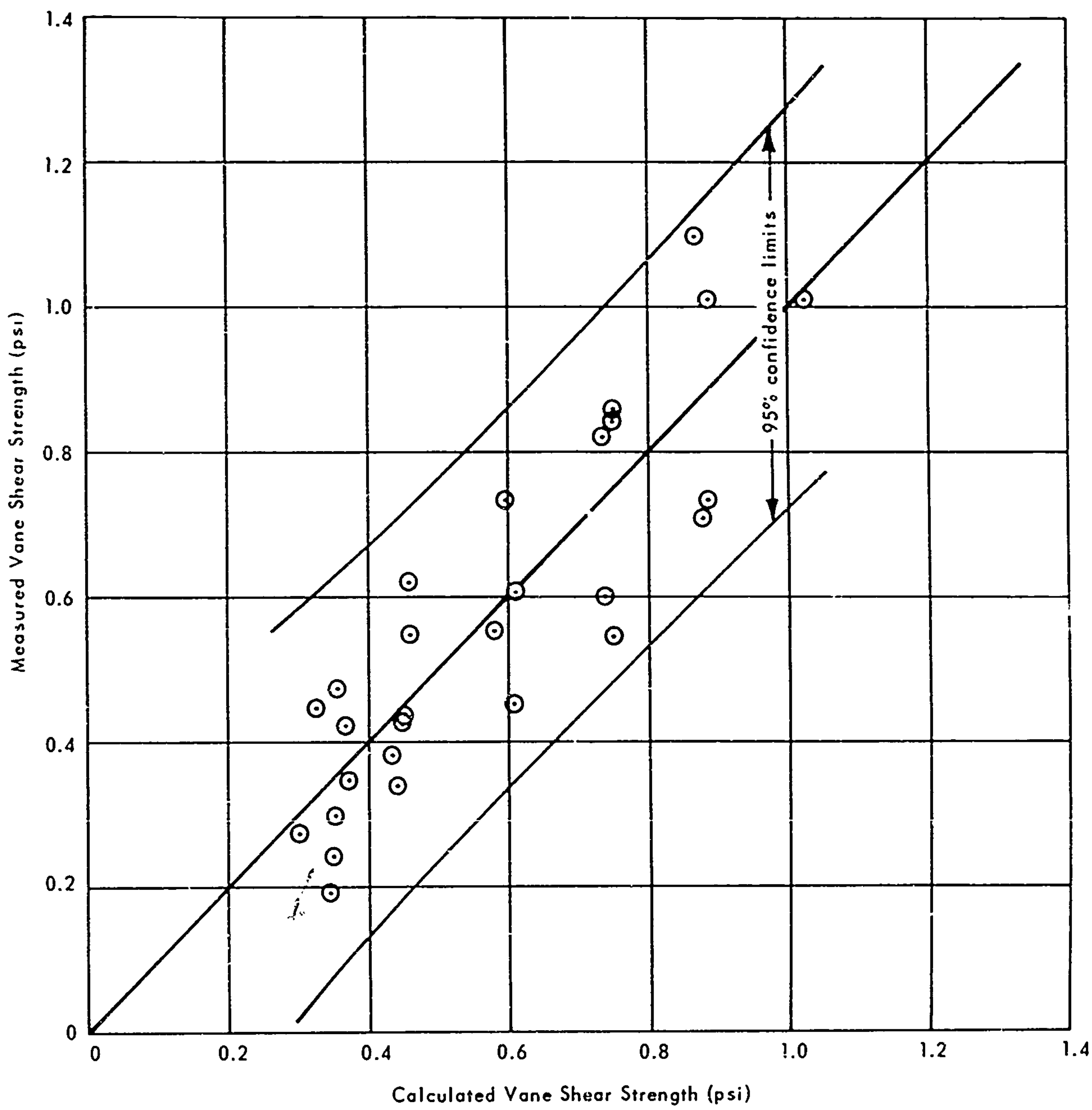

Figure 8. Measured versus calculated vane shear strengths, core MH-1 to MH-8.

In Figure 9 the calculated bulk wet density using the above equation and constants is shown plotted against measured laboratory bulk wet density. There is a definite direct correlation between the measured and calculated values.

Substitution of the constants c_n in the equation will not give a general equation that can be used for all ocean floor areas. Again, as in the equation predicting vane shear strength, the problem is to determine the values of the constants c_n accurately. Four equations could be developed for the four terrain types discussed previously; the four resulting values for each of the constants would be applicable to the respective types. As in the previous equation, the factors that would possibly have influence on the constants may be the sampling technique, sampler characteristics, and testing technique. In addition, the relationship between in-situ and laboratory vane shear values must be established. Once the influence of the factors is determined, the desired equations can be derived with sufficient data from the four terrain types.

The correlation of the various properties with shear strength and bulk wet density is presented here as a possible technique to predict these values when only a few index properties and characteristics are known. The equations presented should not be used indiscriminately because they are applicable only to a very limited area and conditions. These equations are presented to illustrate the technique as a possible method of predicting the values for vane shear strength and bulk wet density. The analysis, however, satisfactorily establishes the relationship between (1) vane shear strength and bulk wet density and (2) their respective independent variables. Upon establishing the values for the constants, these equations could be used for site selection and reconnaissance surveys.

It should not be construed that detailed site investigation, soil testing, foundation design, and analysis could in any instance be replaced by the results of these statistical procedures. If an engineering structure is to be founded on a specific location, that particular location must be investigated and analyzed for its own merits. However, the preliminary studies on the proposed areas of interest could be partially accomplished using the method presented here.

FINDINGS

1. In the foundation analysis, the bearing capacity of the supporting sediments was adequate and the total settlement was tolerable. The calculated average bearing capacity of the supporting sediments was 300 pounds per square foot. The applied load from the STU was approximately 110 pounds per square foot at the base of the footing. The computed total settlement was 1.7 inches. The actual settlements as observed from the mudline markings on material test specimens were approximately 2 inches for STU II-1 and negligible for STU II-2.

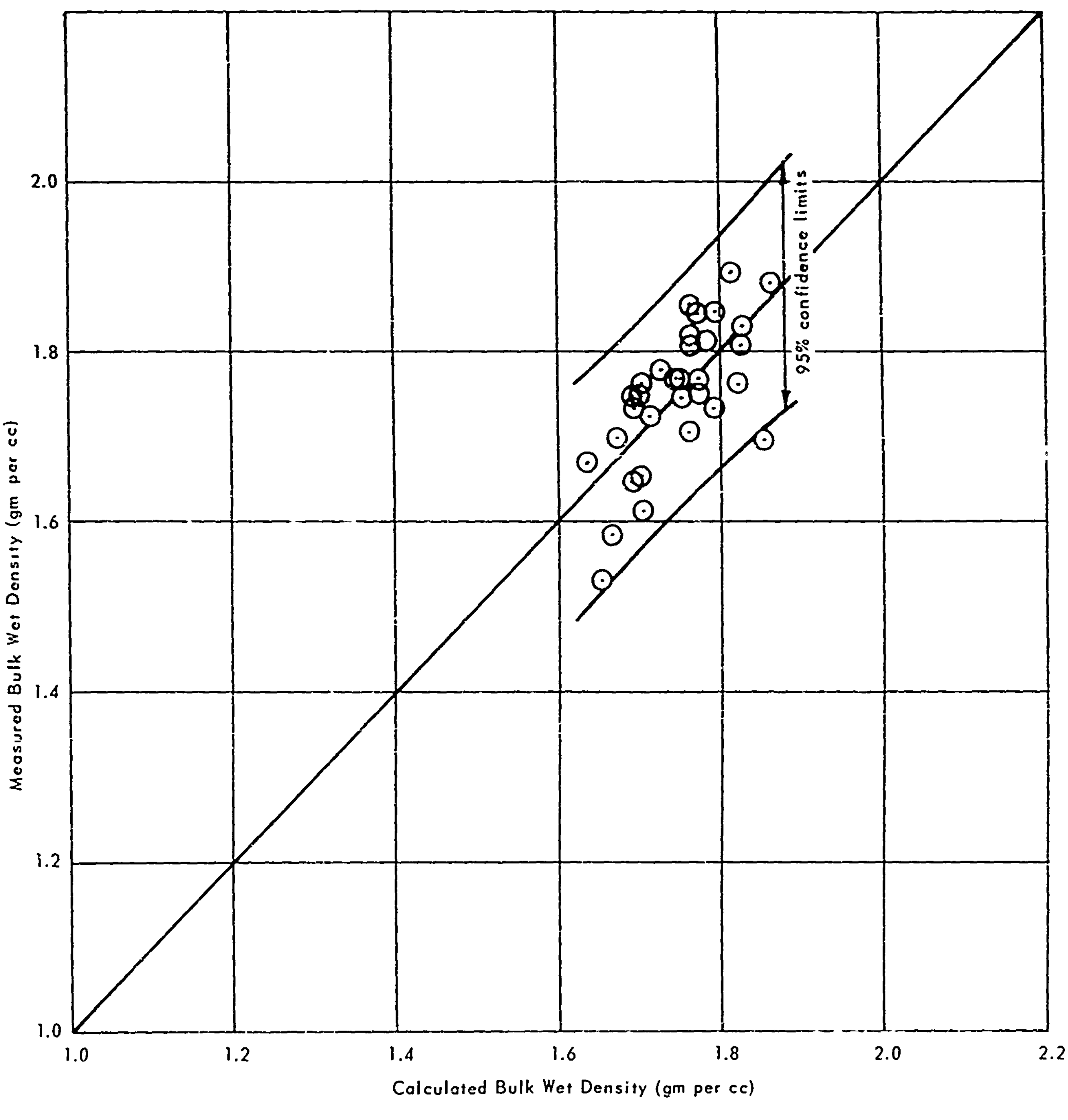

Figure 9. Measured versus calculated bulk wet density, cores MH-1 to MH-8.

2. Some of the sediment properties pertinent to the stability of the structure at the site investigated were:

Sediment Properties	Average	Range
Bulk wet density, gm/cc	1.749	1.530 to 1.895
Vane shear strength, psi	0.650	0.196 to 1.459
Sensitivity	2.8	1.6 to 4.0
Water content, %	46.2	34.7 to 71.5
Specific gravity of solids	2.740	2.608 to 2.843
Void ratio	1.300	0.969 to 1.941
Liquid limit, %	35.5	28.4 to 49.1
Compression index	0.23	0.18 to 0.35
Carbonate content, %	12.78	1.53 to 23.36
Organic content, %	1.35	0.86 to 2.14

In general, the sediments are coarse grained with classifications in the sand, clayey sand, and silty sand groups. Glauconite and quartz were the primary constituents in the plus-325-mesh fraction.

The values for bulk wet density, vane shear strengths (undisturbed and remolded samples), and dry density increases with depth in the sediment column. Sensitivity, water content, void ratio, porosity, and saturated void ratio are inversely proportional to depth in the sediment column. A layer of pebbles was present at the base of core samples MH-2 and MH-4 that would have an influence on the stability of the structure.

3. The statistical study shows that (1) vane shear strength is a function of depth below the sediment surface, liquid limit, and median diameter; and (2) bulk wet density is a function of vane shear strength and sensitivity.

For this area and particular sediment type, the vane shear relationship is

$$VSS = 0.0234(D) - 0.00272(LL) + 0.143(MD) + 0.364$$

The relationship for bulk wet density for this area and sediment type is

$$BWD = 0.0987(VSS) - 0.0571(SN) + 1.843$$

CONCLUSION

The techniques employed in the foundation analysis in this study provided a reasonable estimate of bearing capacity and settlement. The statistical procedures presented can be used to develop equations to predict vane shear strength and bulk wet density for site reconnaissance and site selection purposes.

Appendix A

SUMMARY OF TEST RESULTS

Table A-1. Summary of Test Results for Core MH-1

LATITUDE 34 05.0 N LONGITUDE 120 41.8 W WATER DEPTH 392. FM

INTERVAL (IN)	0-3	6-9	12-15	18-21	24-27
COLOR (GSA NO.)	5Y4/4	5Y3/2	5Y3/2	5Y3/2	5Y3/2
ODOR	H2S	H2S	H2S	H2S	H2S
BULK WET DENSITY (GM/CC)	1.669	1.746	1.805	1.816	1.829
VANE SHEAR STRENGTH (PSI)	0.245	0.427	0.456	0.546	1.011
REMOLDED STRENGTH (PSI)	0.061	0.132	0.209	0.268	0.516
SENSITIVITY	4.0	3.2	2.2	2.0	2.0
WATER CONTENT (P)*	49.6	50.6	41.8	38.5	37.4
SPECIFIC GRAVITY OF SOLIDS	2.769	2.735	2.755	2.716	2.728
DRY DENSITY (GM/CC)	1.116	1.159	1.273	1.311	1.331
VOID RATIO	1.481	1.358	1.165	1.070	1.049
POROSITY (P)	59.7	57.6	53.8	51.7	51.2
SATURATED VOID RATIO	1.373	1.384	1.152	1.046	1.020
LIQUID LIMIT (P)	32.7	39.3	32.7	31.9	32.1
PLASTIC LIMIT (P)	-	-	-	-	-
PLASTICITY INDEX	-	-	-	-	-
LIQUIDITY INDEX	-	-	-	-	-
COMPRESSION INDEX	0.21	0.26	0.21	0.20	0.20
CARBONATE CONTENT (P)	10.54	11.15	6.20	7.17	10.10
ORGANIC CONTENT (P)	1.38	1.28	1.28	1.01	1.28
ACTIVITY	-	-	-	-	-
SAND (P)	76.0	68.0	72.8	74.5	74.8
SILT (P)	11.6	15.2	11.9	11.8	12.4
CLAY (P)	12.4	16.8	15.3	13.7	12.8
MEDIAN DIAMETER (MM)	0.113	0.100	0.103	0.096	0.085
SEDIMENT TYPE	SAND	CLAYEY SAND	CLAYEY SAND	CLAYEY SAND	CLAYEY SAND
MICROSCOPIC ANALYSIS - PLUS 325 MESH FRACTION, (P)					
GLAUCONITE	60	60	60	60	70
QUARTZ	35	35	35	35	25
BENTHONIC FORAMINIFERA	3	2	2	2	2
SPONGE SPICULES	1				
FISH SCALES AND ORGANIC MATERIALS	1	1	1		
HEAVY MINERALS	TR		1		
PLANKTONIC FORAMINIFERA		1		2	2
MINERAL AGGREGATES		1	1		1
ORGANIC FRAGMENTS				1	

REMARKS

THIS CORE IS COMPOSED OF SANDY CLAY. SAND IS MOST ABUNDANT AT THE TOP, POSSIBLY REFLECTING WINNOWING AT THE SURFACE. SAND-SIZED FRAGMENTS ARE MAINLY GLAUCONITE WITH SOME QUARTZ. THE PRESENCE OF GLAUCONITE INCREASES THE PROBABILITY OF WINNOWING. THERE ARE PROMINENT MODERATE OLIVE BROWN (5Y4/4) MOTTLES IN A MATRIX OF OLIVE GRAY (5Y3/2) SEDIMENT. LARGE BENTHONIC FORAMINIFERA VISIBLE IN THE CORE. PLANKTONIC FORAMINIFERA IN COARSE FRACTION ANALYSES.

*(P) REPRESENTS PERCENT

Table A-2. Summary of Test Results for Core MH-2

LATITUDE 34 04.0 N   LONGITUDE 120 41.8 W   WATER DEPTH 412. FM

INTERVAL (IN)	0-3
COLOR (GSA NO.)	5Y4/4
ODOR	H2S
BULK WET DENSITY (GM/CC)	1.766
VANE SHEAR STRENGTH (PSI)	0.351
REMOLDED STRENGTH (PSI)	0.158
SENSITIVITY	2.2
WATER CONTENT (P)*	44.7
SPECIFIC GRAVITY OF SOLIDS	2.843
DRY DENSITY (GM/CC)	1.220
VOID RATIO	1.331
POROSITY (P)	57.1
SATURATED VOID RATIO	1.271
LIQUID LIMIT (P)	30.7
PLASTIC LIMIT (P)	-
PLASTICITY INDEX	-
LIQUIDITY INDEX	-
COMPRESSION INDEX	0.19
CARBONATE CONTENT (P)	16.29
ORGANIC CONTENT (P)	.86
ACTIVITY	-
SAND (P)	79.8
SILT (P)	10.3
CLAY (P)	9.9
MEDIAN DIAMETER (MM)	0.214
SEDIMENT TYPE	SAND
MICROSCOPIC ANALYSIS - PLUS 325 MESH FRACTION, (P)	
GLAUCONITE	70
QUARTZ	25
BENTHONIC FORAMINIFERA	3
PLANKTONIC FORAMINIFERA	1
AGGREGATES	1
SPONGE SPICULES	TR

REMARKS

FIVE INCHES OF SAMPLE ONLY. MODERATE OLIVE BROWN (5Y 4/4) WITH OLIVE GRAY (5Y 3/2) MOTTLES. PEBBLY LAYER AT 5 INCHES INCLUDES MANGANESE NODULE (1 INCH DIAMETER) AND ASPHALTIC MASS (0.5 INCH DIAMETER), BOTH FRACTURED BY CORER. SMALLER PIECES OF GLAUCONITIC AGGREGATES ALSO PRESENT. LARGE BENTHONIC FORAMINIFERA VISIBLE. GLAUCONITE ABUNDANT.

*(P) REPRESENTS PERCENT

Table A-3. Summary of Test Results for Core MH-3

LATITUDE 34 04.8 N LONGITUDE 120 42.7 W WATER DEPTH 396. FM

INTERVAL (IN)	0-3	6-9	12-15	18-21	24-26
COLOR (GSA NO.)	5Y4/4	5Y4/4	5Y4/4	5Y4/4	5Y4/4
ODOR	H2S	H2S	H2S	H2S	H2S
BULK WET DENSITY (GM/CC)	1.699	1.761	1.847	1.855	1.881
VANE SHEAR STRENGTH (PSI)	0.300	0.550	0.609	0.859	1.459
REMOLDED STRENGTH (PSI)	0.086	0.161	0.321	0.297	.0662
SENSITIVITY	3.5	3.4	1.9	2.9	2.2
WATER CONTENT (P)*	47.1	47.2	40.5	38.9	34.7
SPECIFIC GRAVITY OF SOLIDS	2.689	2.708	2.765	2.725	2.747
DRY DENSITY (GM/CC)	1.155	1.196	1.315	1.335	1.396
VOID RATIO	1.326	1.262	1.101	1.041	0.969
POROSITY (P)	57.0	55.8	52.4	51.0	49.2
SATURATED VOID RATIO	1.267	1.278	1.120	1.060	0.953
LIQUID LIMIT (P)	32.5	35.6	31.5	32.2	28.4
PLASTIC LIMIT (P)	-	-	-	-	-
PLASTICITY INDEX	-	-	-	-	-
LIQUIDITY INDEX	-	-	-	-	-
COMPRESSION INDEX	0.20	0.23	0.20	0.20	0.18
CARBONATE CONTENT (P)	10.44	12.98	5.30	15.31	13.34
ORGANIC CONTENT (P)	1.31	1.28	.99	1.03	1.01
ACTIVITY	-	-	-	-	-
SAND (P)	76.3	69.8	72.4	73.1	74.2
SILT (P)	11.5	14.3	14.4	12.3	12.9
CLAY (P)	12.2	15.9	13.2	14.6	12.9
MEDIAN DIAMETER (MM)	0.121	0.100	0.102	0.085	0.085
SEDIMENT TYPE	SAND	CLAYEY SAND	SILTY SAND	CLAYEY SAND	SILTY SAND
MICROSCOPIC ANALYSIS - PLUS 325 MESH FRACTION, (P)					
GLAUCONITE	75	70	70	50	40
QUARTZ	20	25	25	40	50
BENTHONIC FORAMINIFERA	2	3	3	5	3
MINERAL AGGREGATES	2		1		
MICA AND HEAVY MINERALS	1	1		1	5
PLANKTONIC FORAMINIFERA		1		4	2
SPONGE SPICULES	TR		1		

REMARKS

MODERATE OLIVE BROWN (5Y4/4) WITH SLIGHTLY LIGHTER (5Y5/6) MOTTLES OR DISTORTED BEDS. CORE RETAINER DRAGGED EDGES OF BEDS DOWNWARD. VERY SANDY ON SURFACE, LARGELY GLAUCONITE, BECOMING LESS SO DOWNWARD. SAND-SIZED GRAINS ARE LARGELY GLAUCONITE. ELLIPTICAL MOTTLES LOOK LIKE WORM TUBES FILLED WITH DARKER (REDUCED) SEDIMENT.

*(P) REPRESENTS PERCENT

Table A-4. Summary of Test Results for Core MH-4

LATITUDE 34 04.3 N LONGITUDE 120 43.2 W WATER DEPTH 403. FM

INTERVAL (IN)	0-3	6-9
COLOR (GSA NO.)	5Y4/4	5Y3/2
ODOR	H2S	H2S
BULK WET DENSITY (GM/CC)	1.779	1.805
VANE SHEAR STRENGTH (PSI)	0.425	1.280
REMOLDED STRENGTH (PSI)	0.154	0.520
SENSITIVITY	2.8	2.5
WATER CONTENT (P)*	44.8	37.4
SPECIFIC GRAVITY OF SOLIDS	2.784	2.807
DRY DENSITY (GM/CC)	1.229	1.314
VOID RATIO	1.268	1.137
POROSITY (P)	55.9	53.2
SATURATED VOID RATIO	1.247	1.050
LIQUID LIMIT (P)	30.9	46.6
PLASTIC LIMIT (P)	-	-
PLASTICITY INDEX	-	-
LIQUIDITY INDEX	-	-
COMPRESSION INDEX	0.19	0.33
CARBONATE CONTENT (P)	17.32	1.53
ORGANIC CONTENT (P)	.97	1.24
ACTIVITY	-	-
SAND (P)	78.7	75.2
SILT (P)	11.5	9.8
CLAY (P)	9.9	15.0
MEDIAN DIAMETER (MM)	0.189	0.140
SEDIMENT TYPE	SAND	SAND
MICROSCOPIC ANALYSIS - PLUS 325 MESH FRACTION, (P)		
GLAUCONITE	50	60
QUARTZ	40	35
BENTHONIC FORAMINIFERA	5	
PLANKTONIC FORAMINIFERA	2	
AGGREGATES AND HEAVY MINERALS	2	4
SPONGE SPICULES	1	
MICA		1
BROKEN, BENTHONIC FORAMINIFERA		TR

REMARKS

GLAUCONITIC QUARTZOSE SAND IN FAINTLY UNDULATING HORIZONTAL BEDS. BEDS DISTURBED BY CORER. LARGE BENTHONIC FORAMINIFERA AND SOME PLANKTONIC FORAMINIFERA VISIBLE. DARKER MOTTLES COMMON. LAYER OF PEBBLES COMPOSED OF QUARTZITE, SILTSTONE AND PHOSPHATIC NODULES 11 INCHES FROM SURFACE. THESE STOPPED PROGRESS OF THE CORER. SILTSTONE WITH PHOLAD BORINGS, PROBABLY DERIVED FROM SHALLOWER WATER.

*(P) REPRESENTS PERCENT

Table A-5. Summary of Test Results for Core MH-5

LATITUDE 34 06.2 N LONGITUDE 120 41.8 W WATER DEPTH 388. FM

INTERVAL (IN)	0-3	6-9	12-15	18-21	24-27
COLOR (GSA NO.)	5Y4/4	5Y4/4	5Y4/4	5Y4/4	5Y4/4
ODOR	H2S	H2S	H2S	H2S	H2S
BULK WET DENSITY (GM/CC)	1.530	1.646	1.731	1.751	1.761
VANE SHEAR STRENGTH (PSI)	0.277	0.344	1.011	0.822	1.101
REMOLDED STRENGTH (PSI)	0.074	0.106	0.383	0.313	0.471
SENSITIVITY	3.8	3.2	2.6	2.6	2.3
WATER CONTENT (P)*	71.5	57.7	45.8	44.1	44.4
SPECIFIC GRAVITY OF SOLIDS	2.626	2.748	2.727	2.751	2.734
DRY DENSITY (GM/CC)	0.892	1.044	1.187	1.215	1.220
VOID RATIO	1.941	1.632	1.299	1.262	1.242
POROSITY (P)	66.0	62.0	56.5	55.8	55.4
SATURATED VOID RATIO	1.878	1.586	1.249	1.213	1.214
LIQUID LIMIT (P)	49.1	40.9	39.0	36.4	38.5
PLASTIC LIMIT (P)	-	-	-	-	-
PLASTICITY INDEX	-	-	-	-	-
LIQUIDITY INDEX	-	-	-	-	-
COMPRESSION INDEX	0.35	0.28	0.26	0.20	0.25
CARBONATE CONTENT (P)	18.97	22.61	22.78	11.73	20.52
ORGANIC CONTENT (P)	1.30	1.54	1.24	1.52	1.25
ACTIVITY	-	-	-	-	-
SAND (P)	69.1	67.7	68.2	72.6	72.3
SILT (P)	15.7	16.6	15.8	12.5	12.8
CLAY (P)	15.2	15.7	16.0	14.9	14.9
MEDIAN DIAMETER (MM)	0.068	0.068	0.074	0.075	0.074
SEDIMENT TYPE	SILTY SAND	SILTY SAND	CLAYEY SAND	CLAYEY SAND	CLAYEY SAND
MICROSCOPIC ANALYSIS - PLUS 325 MESH FRACTION, (P)					
QUARTZ	70	50	50	60	50
GLAUCONITE	10	10	10	15	10
SHELL DEBRIS	10		5	4	
BENTHONIC FORAMINIFERA	3	10	15	15	15
PLANKTONIC FORAMINIFERA	2	20	10	5	15
SPONGE SPICULES	5	5	5		5
DIATOMS	TR				
HEAVY MINERALS		2	2	1	5
MISC. ORGANIC DEBRIS		2			
RADIOLARIA					TR
AGGREGATES		1	3		
CHARCOAL		TR			
DIATOMS		TR			

REMARKS

GLAUCONITIC SAND THROUGHOUT, SOME QUARTZ, SHELL FRAGMENTS, FORAMINIFERA, SPONGE SPICULES, ETC. COLOR CHANGES SHOW MOTTLING AND BANDING THROUGHOUT. COARSE AND FINE LAYERS DISCERNIBLE IN SOME PLACES.

*(P) REPRESENTS PERCENT

Table A-6. Summary of Test Results for Core MH-6

LATITUDE 34 06.2 N LONGITUDE 120 43.3 W WATER DEPTH 395. FM

INTERVAL (IN)	0-3	6-9	12-15	18-21	24-27	30-33
COLOR (GSA NO.)	5Y4/4	5Y4/4	5Y4/4	5Y4/4	5Y4/4	5Y4/4
ODOR	H2S	H2S	H2S	H2S	H2S	H2S
BULK WET DENSITY (GM/CC)	1.582	1.613	1.703	1.761	1.766	1.697
VANE SHEAR STRENGTH (PSI)	0.447	0.382	0.555	0.601	0.708	1.011
REMOLDED STRENGTH (PSI)	0.115	0.123	0.231	0.216	0.297	0.635
SENSITIVITY	3.9	3.1	2.4	2.8	2.4	1.6
WATER CONTENT (P)*	62.1	60.5	48.7	46.8	44.8	36.6
SPECIFIC GRAVITY OF SOLIDS	2.608	2.694	2.720	2.699	2.795	2.759
DRY DENSITY (GM/CC)	0.976	1.005	1.145	1.200	1.220	1.242
VOID RATIO	1.674	1.681	1.375	1.247	1.294	1.222
POROSITY (P)	62.6	62.7	57.9	55.5	56.4	55.0
SATURATED VOID RATIO	1.620	1.630	1.325	1.263	1.252	1.010
LIQUID LIMIT (P)	39.6	44.0	40.9	35.4	36.0	31.6
PLASTIC LIMIT (P)	-	-	-	-	-	-
PLASTICITY INDEX	-	-	-	-	-	-
LIQUIDITY INDEX	-	-	-	-	-	-
COMPRESSION INDEX	0.27	0.31	0.28	0.22	0.23	0.20
CARBONATE CONTENT (P)	14.26	23.36	11.04	20.29	9.85	13.56
ORGANIC CONTENT (P)	2.14	1.60	1.45	2.06	1.03	1.05
ACTIVITY	-	-	-	-	-	-
SAND (P)	69.7	65.5	66.0	68.0	72.4	69.4
SILT (P)	12.6	16.3	16.5	16.4	13.5	17.0
CLAY (P)	17.7	18.2	17.5	15.6	14.1	13.6
MEDIAN DIAMETER (MM)	0.074	0.072	0.072	0.078	0.077	0.076
SEDIMENT TYPE	CLAYEY SAND	CLAYEY SAND	CLAYEY SAND	SILTY SAND	CLAYEY SAND	SILTY SAND
MICROSCOPIC ANALYSIS - PLUS 325 MESH FRACTION, (P)						
QUARTZ	60	50	60	70	60	60
GLAUCONITE	10	5	5	5	10	10
SHELL DEBRIS	15	10	10	5	5	5
BENTHONIC FORAMINIFERA	5	5		5	5	5
PLANKTONIC FORAMINIFERA	5	20	20	10	15	20
SPONGE SPICULES	5	5				
RADIOLARIA	TR					
FISH TEETH	TR					
AGGREGATES		5	5	5	5	
CHARCOAL					TR	TR
ASPHALT				TR	TR	TR

REMARKS

GLAUCONITIC QUARTZOSE SAND, APPARENTLY HOMOGENEOUS NEAR THE TOP, BECOMING BEDDED DOWNWARD. LOOKS FINER GRAINED THAN OTHER CORES IN THIS SERIES. BENTHONIC FORAMINIFERA VISIBLE. SOME DARK MOTTLES NEAR BASE. LIGHTER AND DARKER LAYERS REVEAL BEDDING NEAR BASE. IT IS ESSENTIALLY HORIZONTAL WITH SOME DISTURBANCE DUE TO SLUMPING, BIOLOGICAL DISTURBANCE, OR DISTURBANCE FROM PASSAGE OF CORER.

*(P) REPRESENTS PERCENT

Table A-7. Summary of Test Results for Core MH-7

LATITUDE 34 06.0 N LONGITUDE 120 44.2 W WATER DEPTH 404. FM

INTERVAL (IN)	0-3	6-9	12-15
COLOR (GSA NO.)	5Y4/4	5Y4/4	5Y3/2
ODOR	H2S	H2S	H2S
BULK WET DENSITY (GM/CC)	1.653	1.721	1.745
VANE.SHEAR STRENGTH (PSI)	0.196	0.437	0.736
REMOLDED STRENGTH (PSI)	0.071	0.145	0.257
SENSITIVITY	2.8	3.0	2.9
WATER CONTENT (P)*	51.9	51.8	45.3
SPECIFIC GRAVITY OF SOLIDS	2.718	2.700	2.739
DRY DENSITY (GM/CC)	1.088	1.134	1.201
VOID RATIO	1.500	1.381	1.283
POROSITY (P)	60.0	58.0	56.2
SATURATED VOID RATIO	1.411	1.399	1.241
LIQUID LIMIT (P)	34.5	36.5	35.1
PLASTIC LIMIT (P)	-	-	-
PLASTICITY INDEX	-	-	-
LIQUIDITY INDEX	-	-	-
COMPRESSION INDEX	0.22	0.23	0.22
CARBONATE CONTENT (P)	9.70	11.91	10.18
ORGANIC CONTENT (P)	1.90	1.39	1.32
ACTIVITY	-	-	-
SAND (P)	78.4	64.4	70.7
SILT (P)	10.0	17.9	14.4
CLAY (P)	11.6	17.7	14.9
MEDIAN DIAMETER (MM)	0.094	0.073	0.088
SEDIMENT TYPE	SAND	CLAYEY SAND	SILTY SAND
MICROSCOPIC ANALYSIS - PLUS 325 MESH FRACTION, (P)			
QUARTZ	50	60	60
GLAUCONITE	40	30	30
BENTHONIC FORAMINIFERA	5	5	5
SPONGE SPICULES	TR	1	1
AGGREGATE	5		
ASPHALT	TR		TR
RADIOLARIA	TR		
PLANKTONIC FORAMINIFERA		2	2
HEAVY MINERALS AND MICA		2	2

REMARKS

RATHER HOMOGENEOUS GLAUCONITIC SAND QUARTZ HAVING VAGUE MOTTLES WITH INDISTINCT BOUNDARIES BECOMING MORE DISTINCT DOWNWARD. MOTTLES OCCUPY ABOUT 50 PERCENT OF CROSS-SECTIONAL SURFACE NEAR THE BASE OF THIS CORE. BENTHONIC FORAMINIFERA VISIBLE.

*(P) REPRESENTS PERCENT

Table A-8. Summary of Test Results for Core MH-8

LATITUDE 34 04.9 N LONGITUDE 120 44.1 W WATER DEPTH 408. FM

INTERVAL (IN)	0-3	6-9	12-15	18-21	24-26
COLOR (GSA NO.)	5Y4/4	5Y3/2	5Y3/2	5Y3/2	5Y3/2
ODOR	H2S	H2S	H2S	H2S	H2S
BULK WET DENSITY (GM/CC)	1.749	1.735	1.819	1.843	1.895
VANE SHEAR STRENGTH (PSI)	0.473	0.621	0.984	0.842	0.734
REMOLDED STRENGTH (PSI)	0.141	0.169	0.318	0.312	0.398
SENSITIVITY	3.4	3.7	3.1	2.7	1.8
WATER CONTENT (P)*	45.1	48.7	41.5	37.5	41.0
SPECIFIC GRAVITY OF SOLIDS	2.779	2.798	2.803	2.749	2.773
DRY DENSITY (GM/CC)	1.205	1.167	1.286	1.340	1.344
VOID RATIO	1.304	1.398	1.179	1.053	1.062
POROSITY (P)	56.6	58.3	54.1	51.3	51.5
SATURATED VOID RATIO	1.253	1.363	1.163	1.031	1.137
LIQUID LIMIT (P)	31.4	35.1	31.0	31.2	32.8
PLASTIC LIMIT (P)	-	-	-	-	-
PLASTICITY INDEX	-	-	-	-	-
LIQUIDITY INDEX	-	-	-	-	-
COMPRESSION INDEX	0.19	0.22	0.19	0.19	0.22
CARBONATE CONTENT (P)	12.85	8.67	7.91	8.73	12.45
ORGANIC CONTENT (P)	1.60	1.55	1.68	1.32	1.27
ACTIVITY	-	-	-	-	-
SAND (P)	81.2	68.5	73.4	72.2	74.6
SILT (P)	8.7	14.8	12.3	12.3	12.6
CLAY (P)	10.1	16.7	14.3	15.5	12.8
MEDIAN DIAMETER (MM)	0.128	0.098	0.092	0.087	0.101
SEDIMENT TYPE	SAND	CLAYEY SAND	CLAYEY SAND	CLAYEY SAND	CLAYEY SAND
MICROSCOPIC ANALYSIS - PLUS 325 MESH FRACTION, (P)					
QUARTZ	45	40	40	40	50
GLAUCONITE	40	50	50	45	40
PLANKTONIC FORAMINIFERA	2	1	4	4	2
HEAVY MINERALS AND MICA	2				
SPONGE SPICULES	1	1	1	TR	1
BENTHONIC FORAMINIFERA	10	8	5	10	5
HEAVY MINERALS AND MICA					2
AGGREGATES				1	
RADIOLARIA					TR
ASPHALT					TR

REMARKS

GLAUCONITIC SAND WITH QUARTZ. BENTHONIC AND PLANKTONIC FORAMINIFERA COMMON. UPPER SAMPLE WITH LITTLE CLAY, BECOMING MORE CLAYEY DOWNWARD. MOTTLES COMMON, SOME DUE TO COLOR CHANGES OVERLAPPING, OTHERS DUE TO TEXTURE CHANGES PROBABLY FROM BIOLOGICAL DISTURBANCE. ASPHALTIC PEBBLE AT 15 INCHES. SOME VESTIGES OF HORIZONTAL BEDDING NEAR THE BASE.

*(P) REPRESENTS PERCENT

Appendix B

GRAPHS OF THE ENGINEERING PROPERTIES OF THE CORE SAMPLES

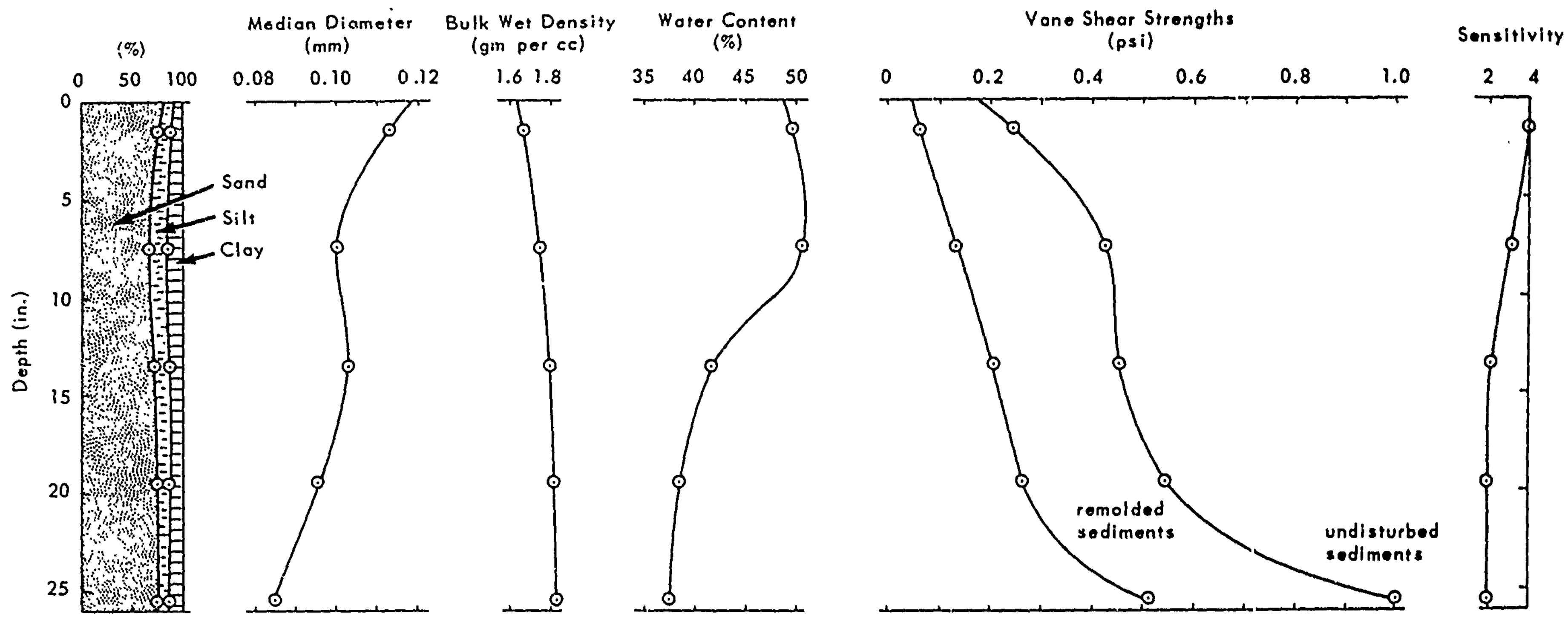

Figure B-1a. Physical properties of core MH-1.

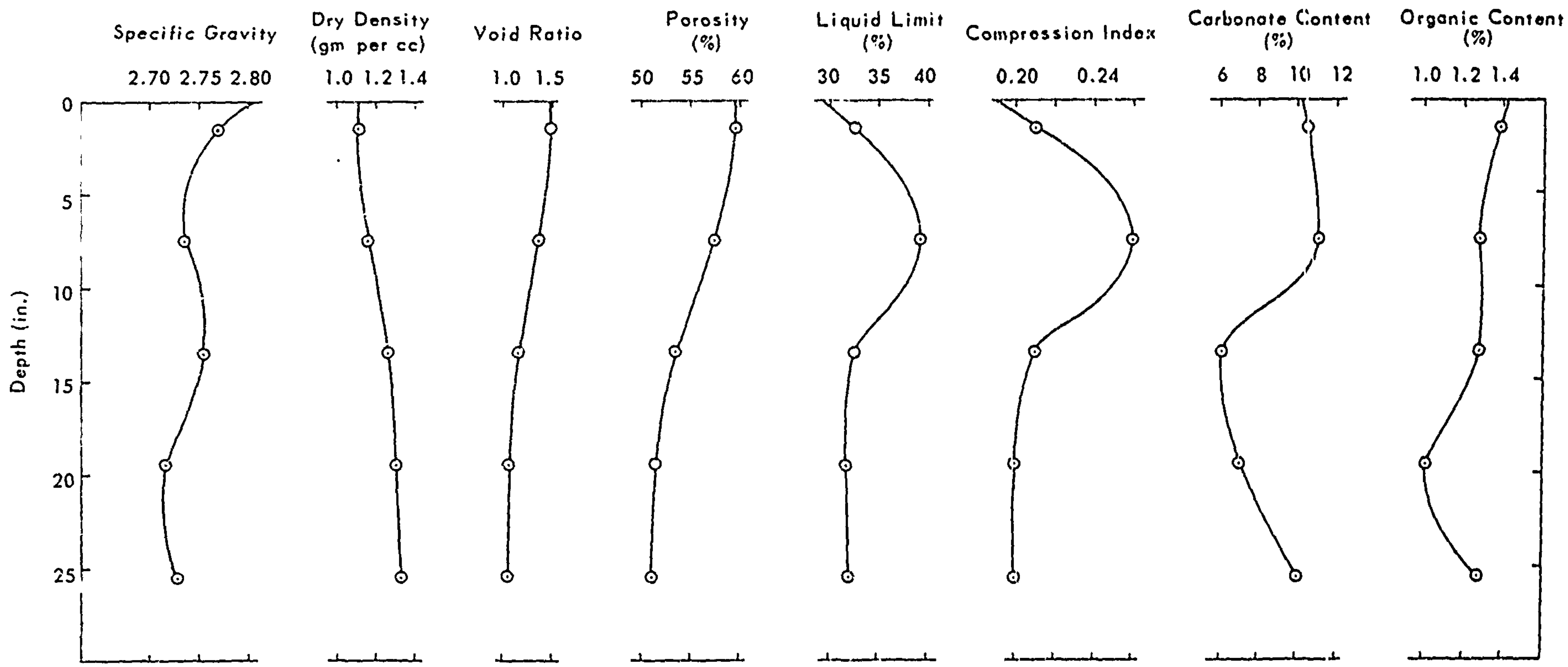

Figure B-1b. Physical properties of core MH-1 (Con'inued).

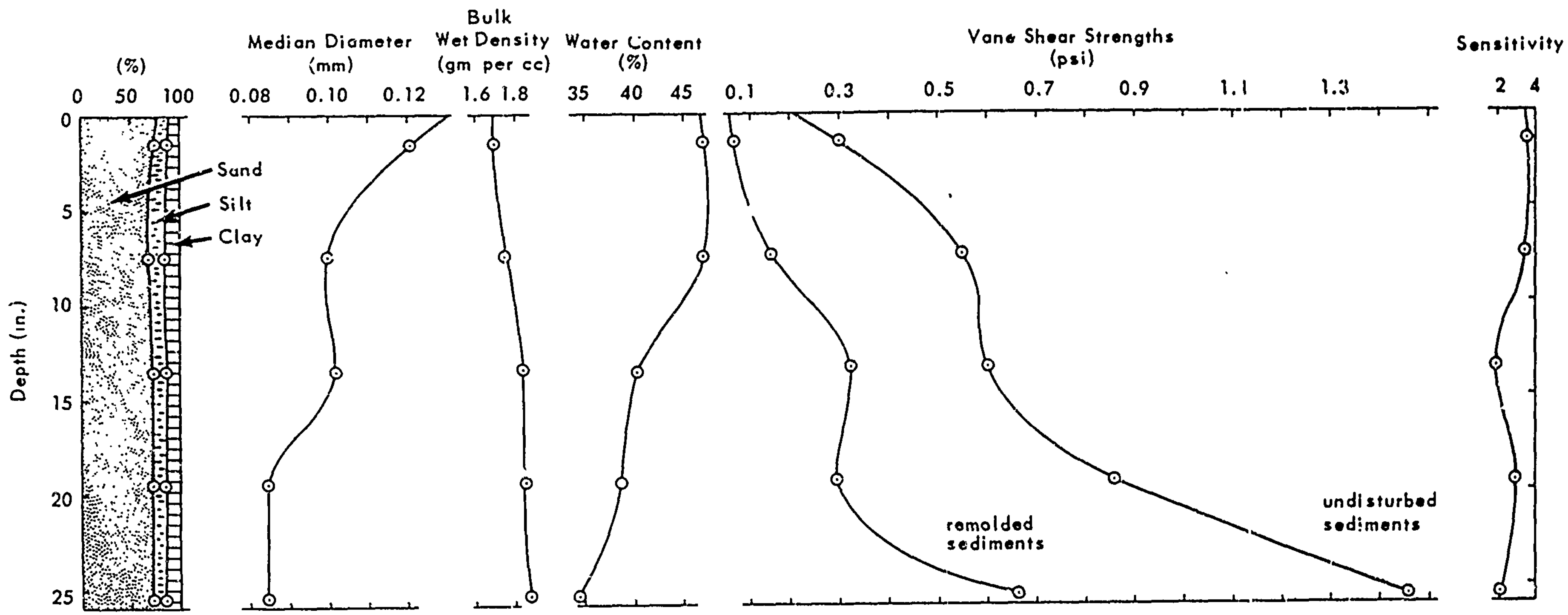

Figure B-2a. Physical properties of core MH-3.

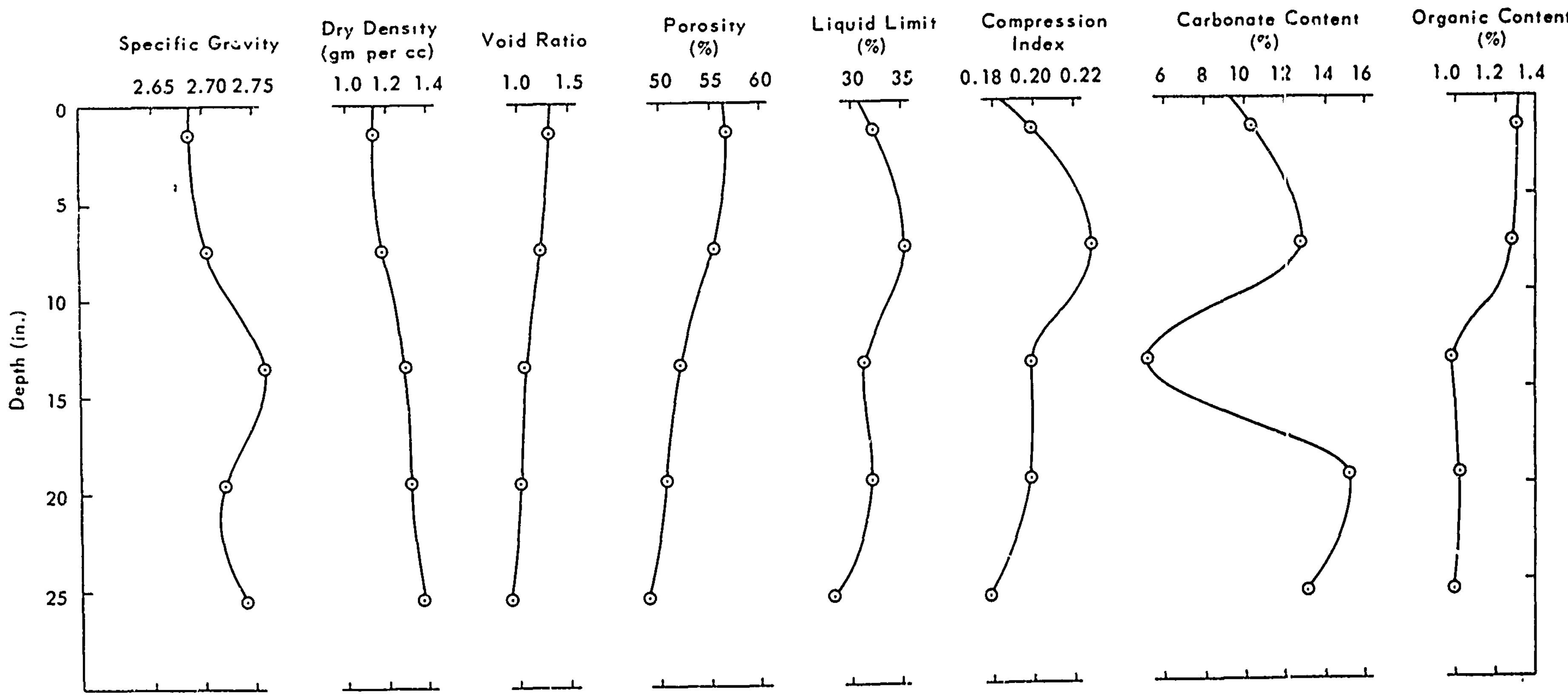

Figure B-2b. Physical properties of core MH-3 (Continued).

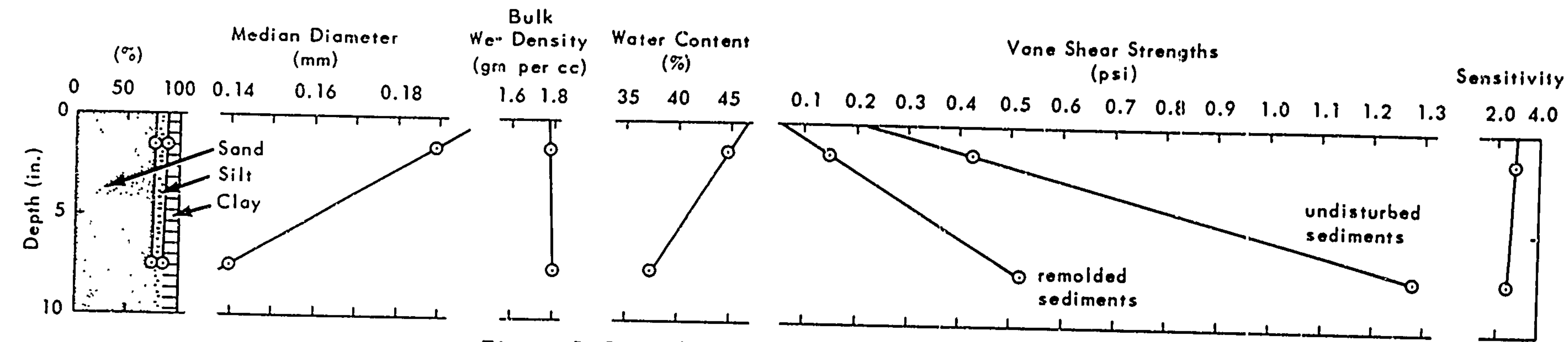

Figure B-3a. Physical properties of core MH-4.

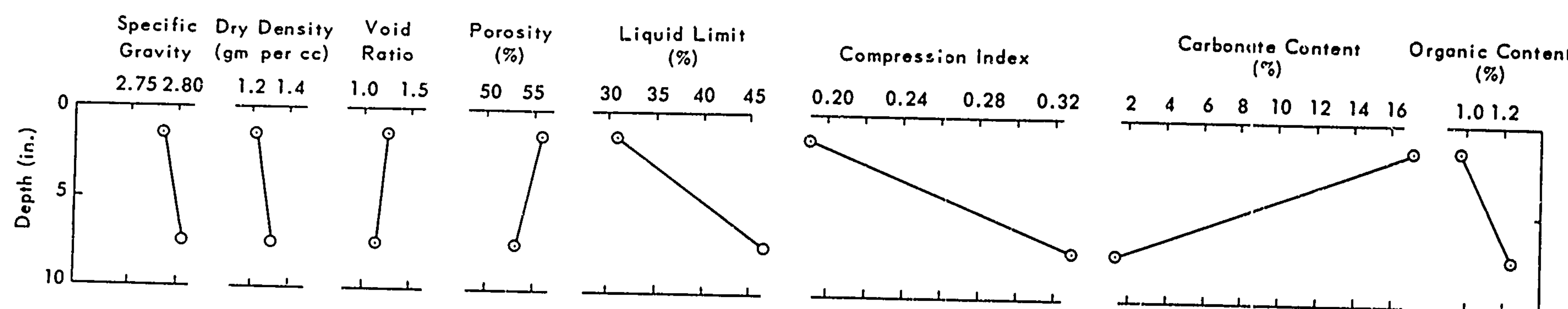

Figure B-3b. Physical properties of core MH-4 (Continued).

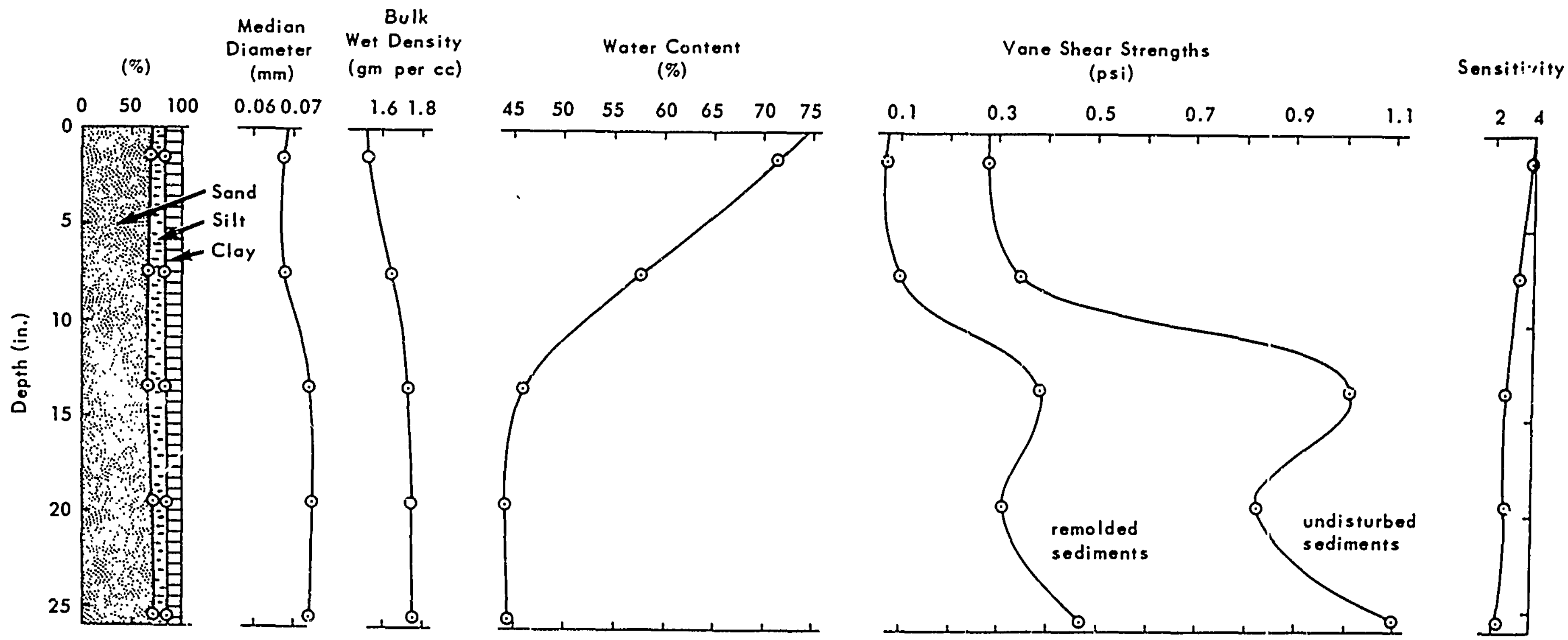

Figure B-4a. Physical properties of core MH-5.

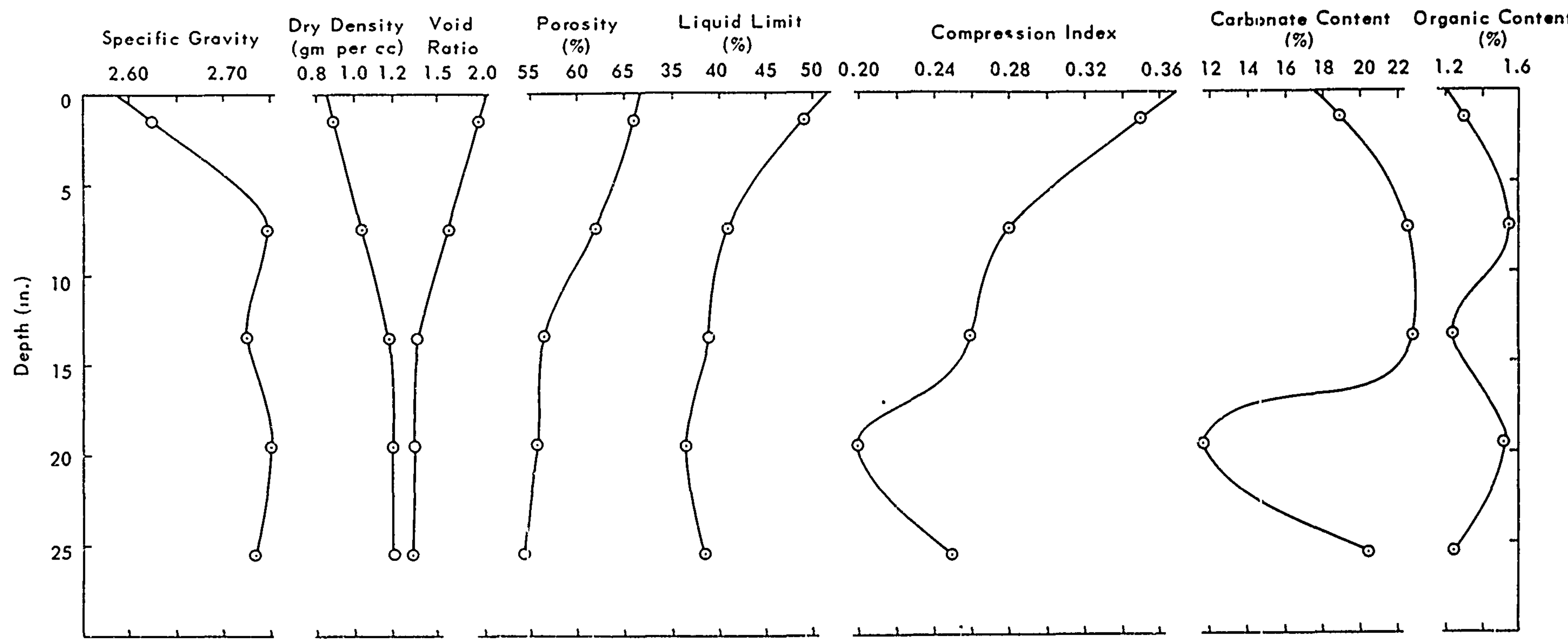

Figure B-4b. Physical properties of core MH-5 (Continued).

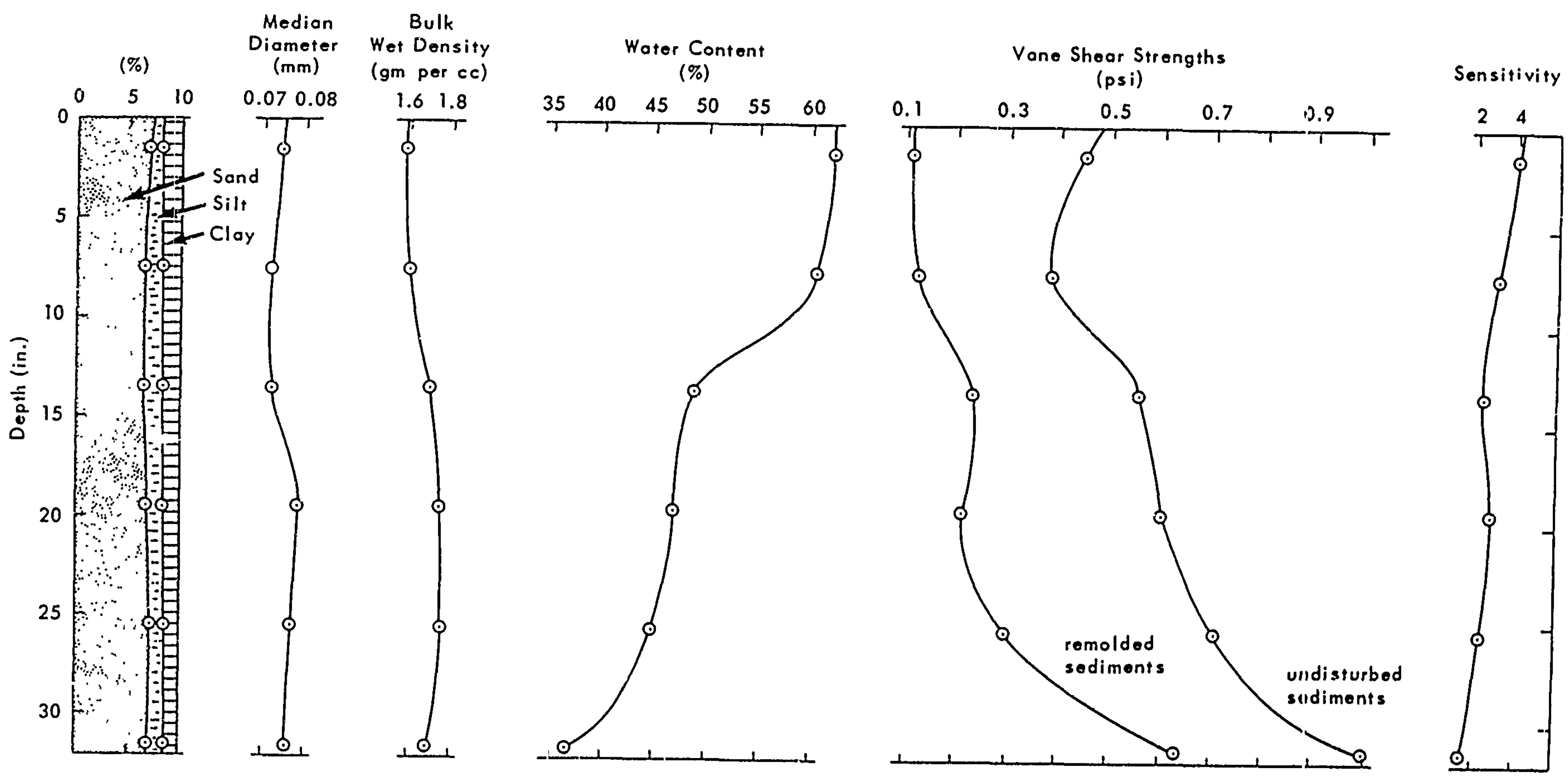

Figure B-5a. Physical properties of core MH-6.

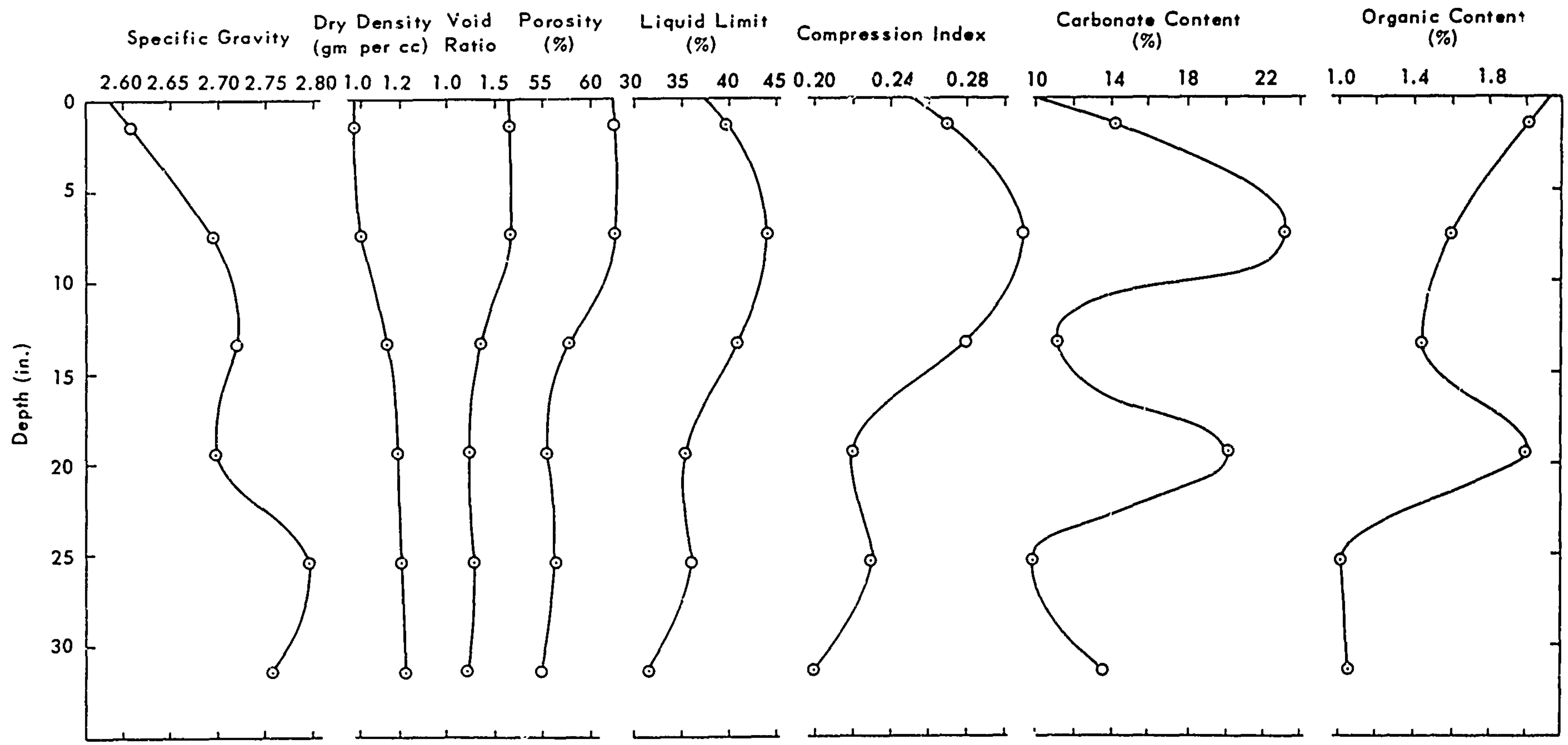

Figure B-5b. Physical properties of core MH-6 (Continued).

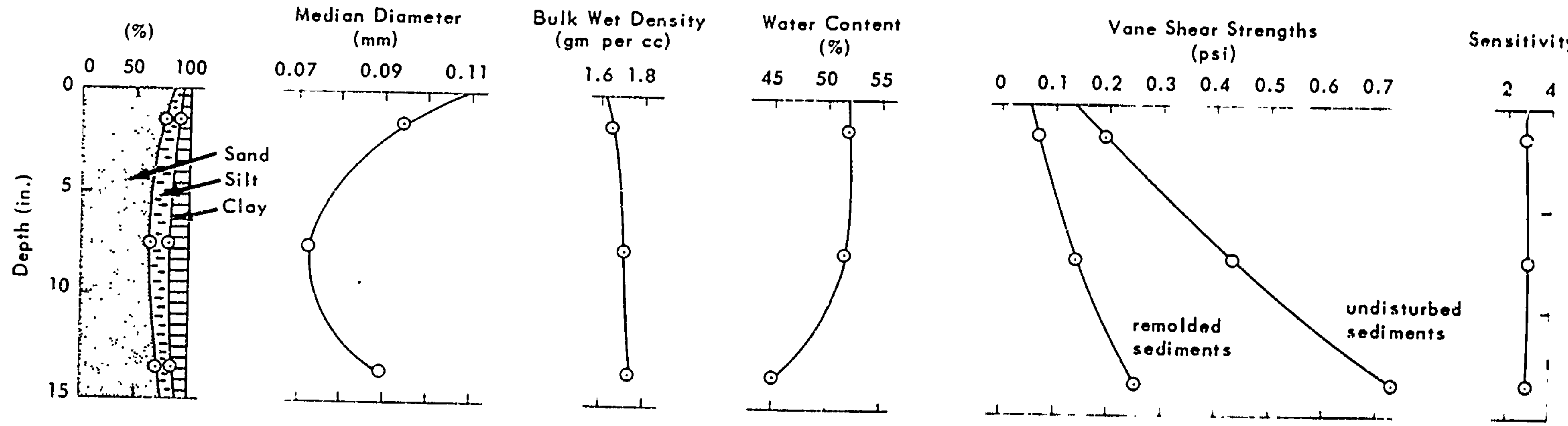

Figure B-6a. Physical properties of core MH-7.

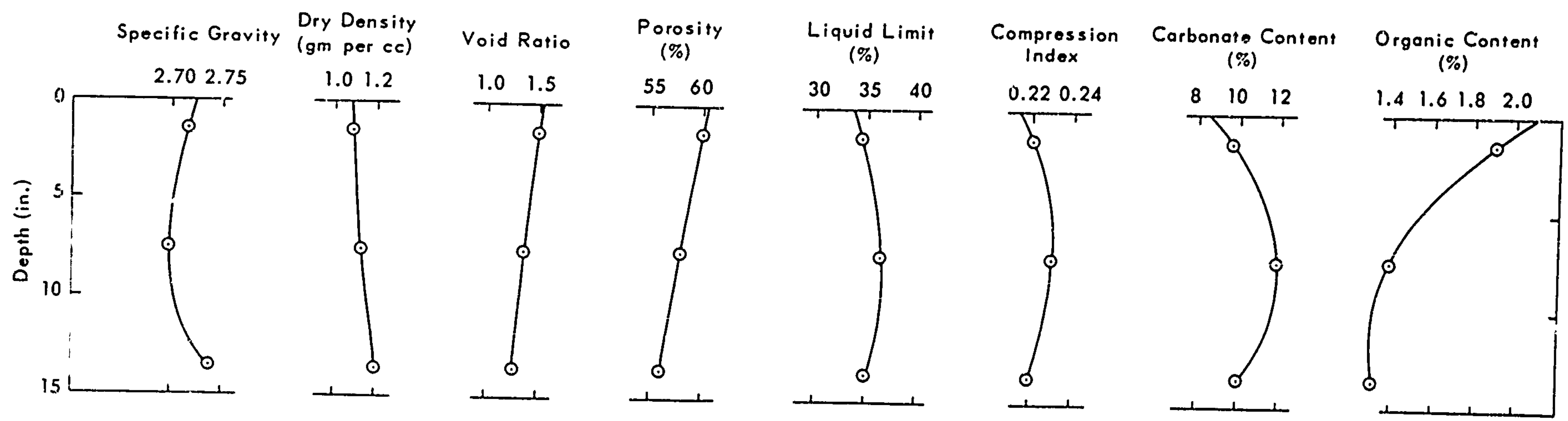

Figure B-6b. Physical properties of core MH-7 (Continued).

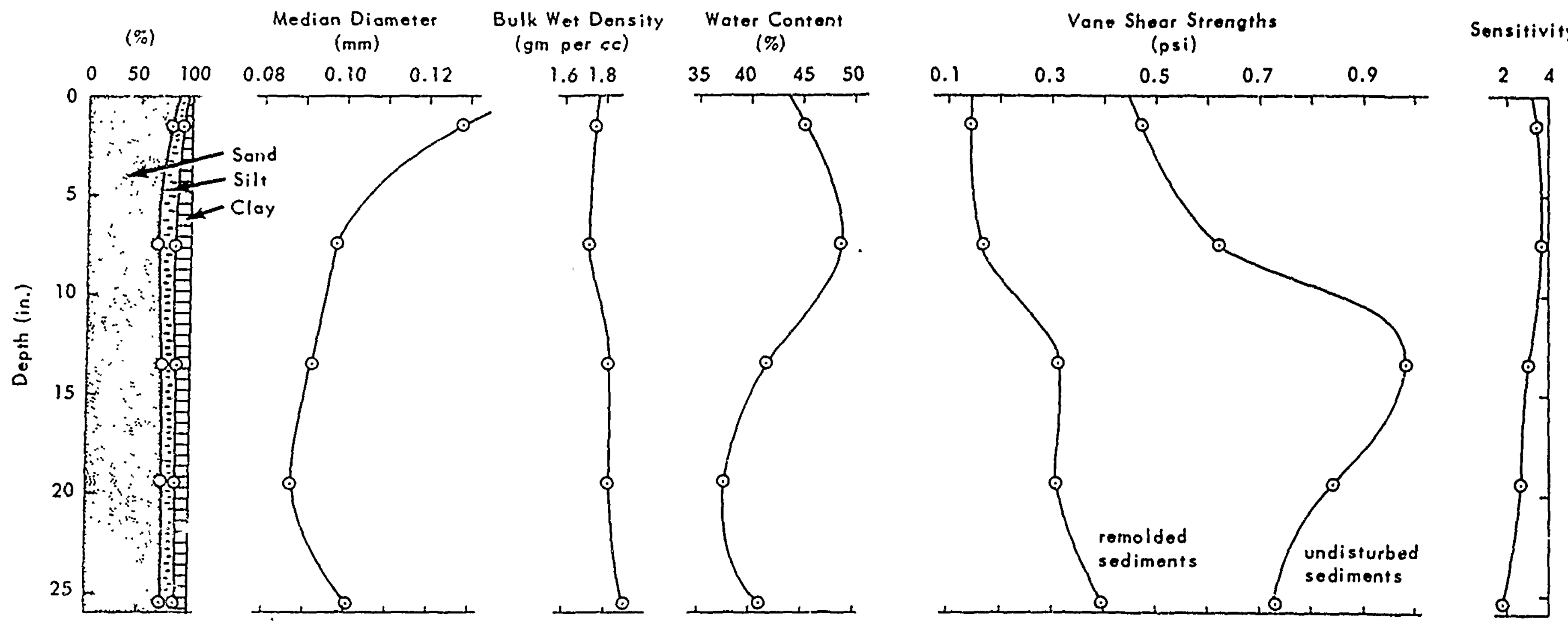

Figure B-7a. Physical properties of core MH-8.

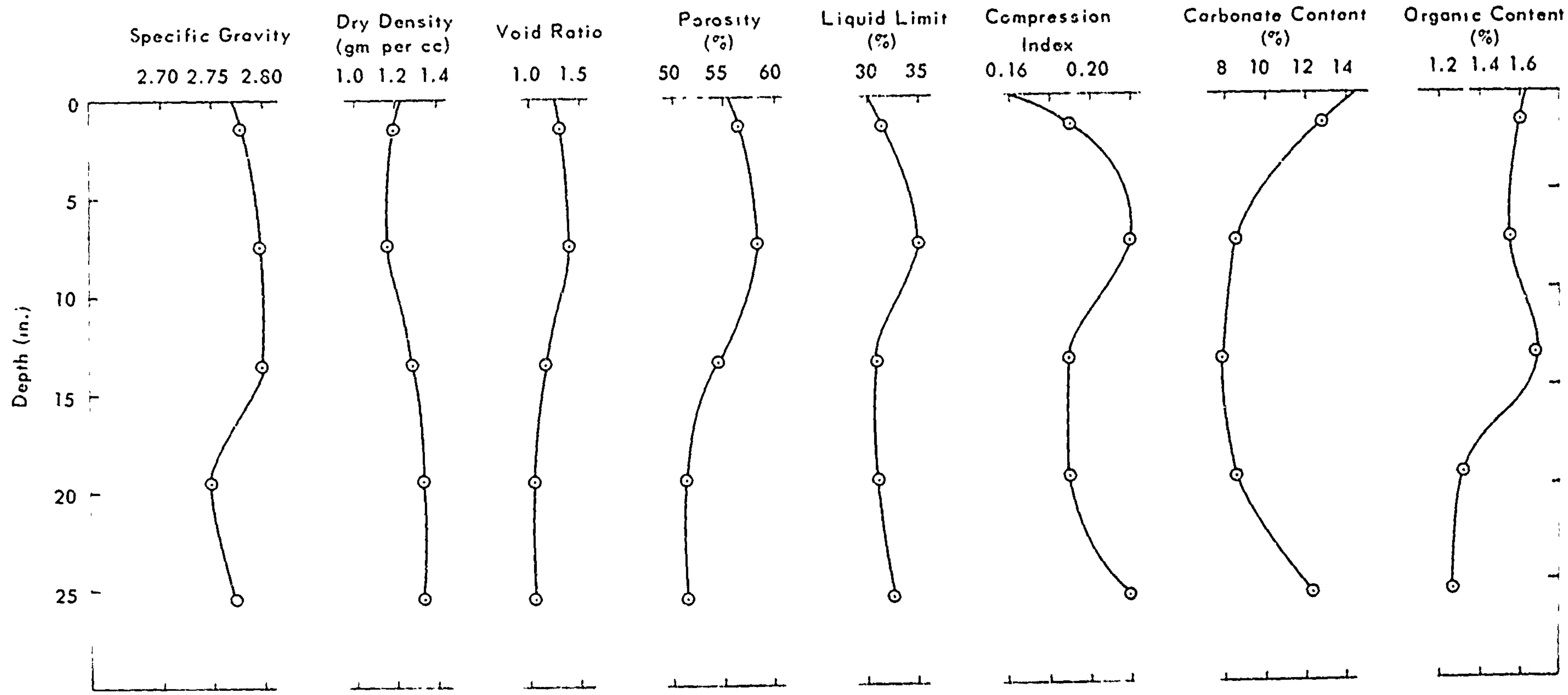

Figure B-7b. Physical properties of core MH-8 (Continued).

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13. ABSTRACT

In April 1964 study was begun of the ocean floor at the proposed site for emplacing Submersible Test Unit II (STU II) series to determine whether the floor would provide a suitable foundation for the STUs. Eight sediment cores were taken to determine the engineering properties of the sediments in an area approximately 2 miles square in the vicinity of 34° 05.5'N, 120° 43.0'W, some 14 miles west of San Miguel Island, California. In addition, a bathymetric chart of the area was constructed using data from the precision depth recorder and navigational instruments aboard the USS Molala. Laboratory tests were conducted on core samples and computations of bearing capacity and settlement were made for the area with the resulting data. The calculated average bearing capacity was 300 pounds per square foot. The applied load of the STU was approximately 110 pounds per square foot. The calculated total settlement was 1.7 inches.

The test results were analyzed statistically to determine the relationships (1) between vane shear strength and depth below the sediment surface, liquid limit, and median particle diameter; and (2) between bulk wet density and vane shear strength and sensitivity. The results indicate the correlations are satisfactory for use in site reconnaissance and site selection studies.

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14. KEY WORDS	LINK A		LINK B		LINK C	
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Marine sediments Engineering properties Vane shear strength Bulk wet density Organic content Carbonate content						

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